Zeppelin Universität Friedrichshafen

Friedrichshafener Institut für Familienunternehmen

Lehrstuhl für Innovation, Technologie & Entrepreneurship

Prof. Dr. Reinhard Prügl

Structuring the Front-End of Innovation: An Empirical Analysis of the Role of Perceived Contextual Factors on Intended Applications and Proficiency of Innovation Fields

Dissertation zur Erlangung des akademischen Grades Dr. rer. pol.

Vorgelegt von Anja Höft

Matrikel-Nummer: 06200712

Erstgutachter: Prof. Dr. Reinhard Prügl

Zweitgutachter: Prof. Dr. Timo Schmid

Vorgelegt am 22. August 2017 in Friedrichshafen

Disputation am 25. Juni 2018 in Friedrichshafen

“Doing the right thing is more important than doing the thing right”

Peter F. Drucker

Danksagung

“Anything is possible if you’ve got enough nerve.”

- *J.K. Rowling*

Dankeschön!

Eine lange Reise geht zu Ende und ich habe vielen wichtigen Menschen zu danken für die große Unterstützung bei diesem Projekt.

Insbesondere geht mein herzlicher Dank an meinen Doktorvater Prof. Dr. Reinhard Prügl, von dem ich mir keine bessere Betreuung hätte wünschen können und der mir stets geholfen hat, den roten Faden im Blick zu behalten. Ohne seine Unterstützung, wäre diese Arbeit nicht möglich gewesen. Weiterer großer Dank gilt Prof. Dr. Timo Schmid für die Betreuung meiner Arbeit und die Beantwortung aller meiner offenen Fragen.

Auf Firmenseite gilt großer Dank meinem Betreuer Peter Guse für das Ermöglichen meiner Forschung, die tolle Betreuung und die vielen Anregungen sowie Daniel Oeschger für die stets inspirierenden Diskussionen und die Freundschaft, die während der Doktorandenzeit entstanden ist. Ich danke ebenfalls dem gesamten wirtschaftlich sozialwissenschaftlichen Doktorandenarbeitskreis für die guten Hinweise und das kritische Hinterfragen sowie den unzähligen Kollegen, die mich während der Doktorandenzeit tatkräftig unterstützt haben.

Ich danke meiner Familie und vor allem meiner Mutter Heike Höft, die mich immer bestärkt und an mich geglaubt hat und mir den Weg bis hierhin möglich gemacht hat.

Ich danke meinem Partner Federico Lentini für seine Geduld, seine kontinuierliche Unterstützung und seine guten Ratschläge.

Zu guter Letzt danke ich meinen Freunden für den moralischen Support, für wertvolles Feedback und vor allem für Verständnis um meine Zeitengpässe, allen voran: Anna-Sophie Baumann, Alexander Komitakis, Dörthe Möller, Jennifer Linhart, Lorenz und Maike Jordan.

Ich widme diese Arbeit der Erinnerung an Patrik Lippmann, der immer daran geglaubt hat, dass ich dieses Projekt beenden kann.

Table of contents

List of Figures

List of Tables

Abbreviations

B-2-B	Business to Business
FCS	Fully Conditional Specifications
FEI	Front-End of Innovation
NPD	New Product Development
IMA	Innovation Management Ambassador
IF	Innovation Field
iNPD	Integrated New Product Development
IoT	Internet of Things
MAR	Missing at Random
MCAR	Missing Completely at Random
MICE	Multivariate Imputation by Chained Equations
NCD	New Concept Development Model
OEM	Original Equipment Manufacturer
PMM	Predictive Mean Matching
R&D	Research and Development
SOD	Start of Development
TAM	Technology Acceptance Model
VC	Venture Capital

Abstract

The global economy has gained momentum in recent years, with advances in technology and digitalization leading to shorter product life cycles, increased competition, and transformed industries. These circumstances call for the need for constant innovation. Organizations are required to act and adapt quickly to technological changes, dynamic markets, competitive threats, and rapidly altering customer needs, without losing focus of their established business. Two notions are important for organizations in this setting: (1) reaching ambidexterity and (2) structuring the front-end of innovation.

Ambidextrous companies, which own the ability to balance between innovation activities that exploit current competencies (exploitation) and those that explore new competencies (exploration), are more successful than companies which concentrate on only one of these activities (Gibson & Birkinshaw, 2004; He & Wong, 2004; Jansen, Van Den Bosch, & Volberda, 2006; Katila & Ahuja, 2002; C. Kim, Song, & Nerkar, 2012). However, both exploration and exploitation require the allocation of resources, causing a trade-off, which makes it difficult to perform the combination of both (Greve, 2007; Levinthal & March, 1993). Previous research does not focus on how organizations can adapt their innovation activities in order to reach ambidexterity (Cantarello, Martini, & Nosella, 2012; Judge & Blocker, 2008; Z. Wei, Yi, & Guo, 2014).

Managing innovations poses an increasingly daunting task for organizations, demanding different requirements regarding the innovation management process. Managing innovation through a structured innovation process facilitates the creation and planning of innovation to transform ideas into marketable products. The first stage of this process – the front-end of innovation – is of significant meaning, since activities in the front-end of innovation are strongly linked to innovation success (Dwyer & Mellor, 1991; Markham, 2013; Moenart, De Meyer, Souder, & Deschoolmeester, 1995; Reid & de Brentani, 2004). The creation of value and competitive advantage takes primarily place in the front-end of innovation, and the actual costs of mismanagement can only be discovered at later stages (Markham, 2013; Reid & de Brentani, 2004; P. Smith & Reinertsen, 1991).

A concept to foster ambidexterity and structure the front-end of innovation described mainly by practitioners are so-called innovation fields (Cooper, Edgett, & Kleinschmidt, 2004; Crawford, 1980; Hambrick & Fredrickson, 2001; Khurana & Rosenthal, 1998; Reid & de Brentani, 2004; Talke, Salomo, & Rost, 2010). Innovation fields establish guidelines that determine search strategy, scope, depth, and locus of innovation search by setting search boundaries. Literature describes different types of applications for innovation fields such as strategic purposes, ideation, lifting synergies, technology intelligence and portfolio extension. With innovation fields, organizations (1) can structure the front-end of innovation and align corporate objectives to innovation activities and (2) have an instrument at hand to facilitate the shift of resources and to prioritize innovation activities according to the balance between exploitation and exploration, thereby fostering ambidexterity.

However, research on innovation fields is scarce, thus, the objective of this dissertation is to examine how and why perceived contextual factors influence the intended application and perceived proficiency of innovation fields in the front-end of innovation.

The theoretical foundation is based on the theory of organizational learning. A research framework is derived from acknowledged literature, focusing on (1) strategic orientation, (2) organizational context and (3) external environment as main contextual factors influencing the intended application of innovation fields. An explorative research design is followed, composed of an embedded single case study design using a mixed-methods approach. As a case, a corporate R&D division of a Germany-based company is selected. First, a qualitative study with semi-structured interviews is conducted, followed by a quantitative survey to get a more comprehensive picture of the role of perceived contextual factors influencing intended innovation field applications and proficiency.

Based on the underlying empirical research, distinct differences regarding perceived contextual factors and their influence on intended innovation field applications and proficiency have been identified. Notably, the perceived contextual factors vary across the different types of applications for innovation fields. Overall, the strategic orientation and external environment have a strong influence on the intended innovation field applications and proficiency, while organizational context only play a minor role. Furthermore, the findings substantiate the use of different types of applications for innovation fields in the front-end of innovation. This study contributes to theory by creating a research framework linking perceived contextual factors to intended innovation field applications and proficiency. Finally, this dissertation delivers a comprehensive description of innovation field applications. The findings enhance the existing body of knowledge regarding innovation research, specifically regarding the front-end of innovation and innovation fields as well as organizational learning. Besides the advancement of scientific knowledge, managerial implications are drawn for the application of innovation fields in a corporate context.

1 Introduction

In this chapter, the motivation, research focus and structure of the thesis is outlined.

STRUCTURE OF CHAPTER 1: INTRODUCTION
1.1 Motivation 1.2 Research Focus 1.3 Thesis Structure

Figure 1: Chapter Overview of Introduction

Notes:
Source: own representation

1.1 Motivation

Innovation as a Driver of Sustainable Success and Competitive Advantage

The global economy has gained momentum in recent years, with advances in technology and digitalization leading to shorter product life cycles and increased competition worldwide. Trends such as the Internet of Things, robotics or artificial intelligence have the potential to influence and transform whole industries (Wellers, 2015; World Economic Forum, 2014). These circumstances call for the need for constant innovation within and beyond the current scope of business, to retain and gain sustainable competitive advantage and long-term success (Hitt, Ricarti Costa, & Nixon, 1998; Legnick-Hall, 1992; K. A. Smith, Vasudevan, & Tanniru, 1996, p. 41; Teece, 2007).

Innovation remains a high priority for organizations. According to a study by BCG, almost 80% of companies evaluate innovation as one of their most important topics (Ringel, Taylor, & Zablit, 2015, p. 3). In 2015, the top 1,000 companies that invest in R&D increased their expenses by 5%, spending $680 billion on R&D activities. These investments reflect a long-term trend of companies investing in innovation activities (Jaruzelski, Staack, & Schwartz, 2015). However, such high investments do not guarantee success. Even once-renowned industry leaders that have been successful for many years – such as Kodak or Nokia – are not immune to falling into oblivion by underestimating disruptive trends or making wrong investment decisions (Lucas & Goh, 2009; Pisano, 2015; Vuori & Huy, 2016).

Thus, organizations are required to act and adapt quickly to technological changes, dynamic markets, competitive threats, and rapidly-altering customer needs, while not neglecting their primary business. Two notions are important for organizations in this setting: (1) reaching ambidexterity and (2) structuring the front-end of innovation, primarily the so-called strategic phase.

The theory of organizational learning is described as the ability of an organization to generate and reflect experiences, that subsequently shape decision-making (Levitt & March, 1988, p. 319; McKee, 1992, p. 233; Shrivastava & Grant, 1985, p. 98). In the context of innovation, organizational learning theory highlights that companies with the ability to balance between innovation activities that exploit current competencies and those that explore new competencies are more successful than those companies that only focus one of those search strategies (He & Wong, 2004, p. 484; Jansen et al., 2006; Katila & Ahuja, 2002, p. 1191; C. Kim et al., 2012, p. 1193). The balance between exploration and exploitation is also known as ambidexterity, reflecting a decisive factor for organizations' long-term success (Gibson & Birkinshaw, 2004, p. 212; Levinthal & March, 1993). However, both of these activities require the allocation of resources, thus causing a trade-off, making it difficult to perform the combination of both (Greve, 2007, p. 945; Levinthal & March, 1993, p. 101).

Previous research in organizational learning theory does not offer solutions on how organizations can adapt their innovation activities to reach ambidexterity (Z. Wei, Yi, et al., 2014, p. 833). Thus, the question arises concerning how the balance between exploration and exploitation can be fostered, especially regarding the management of innovation.

Structuring the Strategic Phase of the Front-End of Innovation

Through the aforementioned challenges, managing innovations poses an increasingly daunting task for organizations, demanding different requirements regarding the innovation management process (Drazin & Bird Schoonhoven, 1996, p. 1081; Keupp, Palmie, & Gassmann, 2013, p. 368). Structuring the innovation process can facilitate the creation and planning of innovation (Cooper, 2008, p. 213). Within the innovation process, the front-end of innovation holds significant meaning for the whole innovation process, since activities in the front-end of innovation are strongly linked to innovation success (Booz Allen & Hamilton, 1982; Dwyer & Mellor, 1991; Jaruzelski, Loehr, & Holman, 2012; Markham, 2013; Moenart et al., 1995; Reid & de Brentani, 2004). The creation of value and competitive advantage takes place in the front-end of innovation, while the actual costs of mismanagement can only be discovered at later stages (Markham, 2013; Reid & de Brentani, 2004; P. Smith & Reinertsen, 1991). The front-end of innovation usually comprises idea generation, idea evaluation, concept development and ends with the start of development (SOD). One often-neglected phase within the front-end of innovation is the **strategic phase** (Hertenstein & Platt, 2000, p. 314; Khurana & Rosenthal, 1998, p. 65; Koen & Bertels, 2010, p. 236; P. Smith & Reinertsen, 1991, p. 59). It precedes the idea generation phase and comprises two main tasks: First, it links the objectives of the corporation with those of innovation by defining an **innovation strategy** that determines the search boundaries, scope, and locus of innovation search. Second, it aligns and guides the current portfolio of innovation activities by allocating resources accordingly (Khurana & Rosenthal, 1998, p. 59; Oliveira & Rozenfeld, 2010, p. 1340). The strategic phase helps to facilitate go/no-go decisions in the front-end of innovation, distribute resources according to corporate objectives and is highlighted as an important success factor within the front-end of innovation by numerous authors (Booz Allen & Hamilton, 1982; Khurana & Rosenthal, 1998; J. Kim & Wilemon, 2002b; Mootee, 2011; Oliveira & Rozenfeld, 2010; Russell & Tippett, 2008; Zhang & Doll, 2001). Corporations with a strategic phase in the front-end of innovation appear to be more successful and possess ideas that deliver more sustainable value (Booz Allen & Hamilton, 1982, p. 6; Cooper & Kleinschmidt, 1987, 1994; Khurana & Rosenthal, 1998, p. 63; Koen et al., 2001, p. 49). Having an innovation strategy holds special importance for an organization in times of rapid change and market turbulence to adapt to altered environments (Helfat et al., 2007, p. 1; Nag, Hambrick, & Chen, 2007, p. 942). However, the existence of a documented innovation strategy or its communication to the organization is often missing (Booz Allen & Hamilton, 1982, p. 5; Dwyer & Mellor, 1991, p. 43; Koen & Bertels, 2010, p. 236; P. Smith & Reinertsen, 1991, p. 59). In addition to the challenge of communicating the innovation strategy, its deduction into practicable guidelines and innovation activities is challenging (Khurana & Rosenthal, 1998, p. 65). A current benchmark study underlines this finding by stating that more than half of the companies in their study have difficulties aligning innovation activities with corporate goals (Staack, Huff Eckert, Cole, & Riggs, 2017, p. 7). Furthermore, it is reported that it is increasingly important for companies to think about where to invest money for innovation activities, rather than how much money (Staack et al., 2017, p. 5).

In order to effectively manage the front-end of innovation and secure the alignment of corporate objectives and innovation activities, a formalization of the front-end of innovation is proposed, although it is discussed controversially (Khurana & Rosenthal, 1998; J. Kim & Wilemon, 2002a; Markham, 2013; Nobelius & Trygg, 2002).

Innovation Fields as a Structuring Element of the Front-End of Innovation

A concept to structure the strategic phase of the front-end of innovation that has been mainly described by practitioners are so-called **innovation fields** (Cooper et al., 2004; Crawford, 1980; Hambrick & Fredrickson, 2001; Khurana & Rosenthal, 1998; Mootee, 2011; Reid & de Brentani, 2004; Talke et al., 2010). Several companies report applying innovation fields, such as 3M, Procter & Gamble, Medtronic, and UPS (Laurie, Doz, & Sheer, 2006; Salomo, Talke, & Strecker, 2008).

Innovation fields are an instrument to structure the strategic phase of the front-end of innovation by establishing guidelines that determine the search strategy, scope, depth, and locus of innovation search by setting search boundaries. These guidelines are “related by one common theme, which can be a customer need, a core competence, a technology platform, or any combination of these” (Salomo et al., 2008, p. 561). The innovation strategy is determined by the sum of innovation fields.

Innovation fields are known by literature under different terms, such as *target business areas*, *strategic arenas*, *strategic innovation programs* or *growth platforms* (Buggie, 2002; Colarelli O’Connor & Ayers, 2005; Cooper et al., 2004; Crawford, 1980). Besides, literature suggests a variety of different applications for innovation fields: innovation fields are used for strategic purposes, such as strategy formulation, focus, and portfolio management. In addition they serve for technology intelligence, ideation, lifting synergies, and portfolio extension (Buggie, 2002; Colarelli O’Connor & Ayers, 2005; Gillier, Piat, & Truchot, 2010; Laurie et al., 2006; Salomo et al., 2008; Wellensiek, Orilski, & Schuh, 2009). Furthermore, they are reported to enhance productivity and innovativeness (Danneels, 2002; Salomo et al., 2008; Talke et al., 2010).

With innovation fields structuring the strategic phase of the front-end of innovation, organizations have an instrument at hand to facilitate the shift of resources and prioritize innovation activities according to their contribution towards exploitation and exploration. Accordingly, they foster ambidexterity by balancing explorative innovation fields with exploitative innovation fields (Raisch & Birkinshaw, 2008, p. 401), thereby helping to achieve long-term success and competitive advantage (Gibson & Birkinshaw, 2004, p. 212).

1.2 Research Focus

Despite its acknowledged importance, only little empirical research has been conducted regarding the front-end of innovation, (J. Kim & Wilemon, 2002a; Koen & Bertels, 2010; Markham, 2013; Verworn, Herstatt, & Nagahira, 2008). Kahn et al (2003) propose the front-end of innovation as a topic for further research, while Keupp et al. (2013) address the strategic management of innovation as an important topic for future research (Kahn, Franzak, & Griffin, 2003, p. 193; Keupp et al., 2013, p. 368). Regarding innovation fields, research is even scarcer, given that most of the literature on innovation fields is conceptual. There are only two recent empirical papers addressing the performance of innovation fields (Salomo et al., 2008; Talke et al., 2010). Research on the contextual factors influencing the application of innovation fields has received even less attention from scholars, leaving the implications of innovation fields unexplored. Several scholars ask for a better theoretical understanding of this concept, a better structure regarding the typology and more attention towards the characteristics and circumstances of innovation field application (Hatchuel, Le Masson, & Weil, 2001, p. 13; Salomo et al., 2008, p. 569; Wellensiek et al., 2009, p. 3). Nonetheless, to date, no comprehensive study has outlined the different applications for innovation fields and the role of contextual factors influencing their application and proficiency. Thus, the objective of this thesis is to determine the role of perceived contextual factors on intended innovation field applications and their perceived proficiency in a corporate context.

The following research questions will be examined:

1. How and why do perceived contextual factors influence the intended application of innovation fields?
2. How and why do perceived contextual factors influence the perceived proficiency of innovation fields?

Embedded into the theoretical strands of organizational learning and ambidexterity, a research framework is derived, focusing on three main contextual factors: (1) strategic orientation, (2) organizational context and (3) external environment.

An explorative research design is followed in this thesis, since research on innovation fields is scarce. The empirical research comprises an embedded single case study using a mixed-methods approach. As a case, a corporate R&D division from a Germany-based company is selected. The mixed-methods approach entails a qualitative study, followed by a quantitative one. First, twenty-two interviews are conducted to explore innovation field applications and to gain insights into perceived contextual factors and intended innovation field applications. Subsequently, a quantitative study is conducted, to obtain a more comprehensive picture of the role of perceived contextual factors on intended innovation field applications and perceived proficiency. Figure 2 shows the applied research framework.

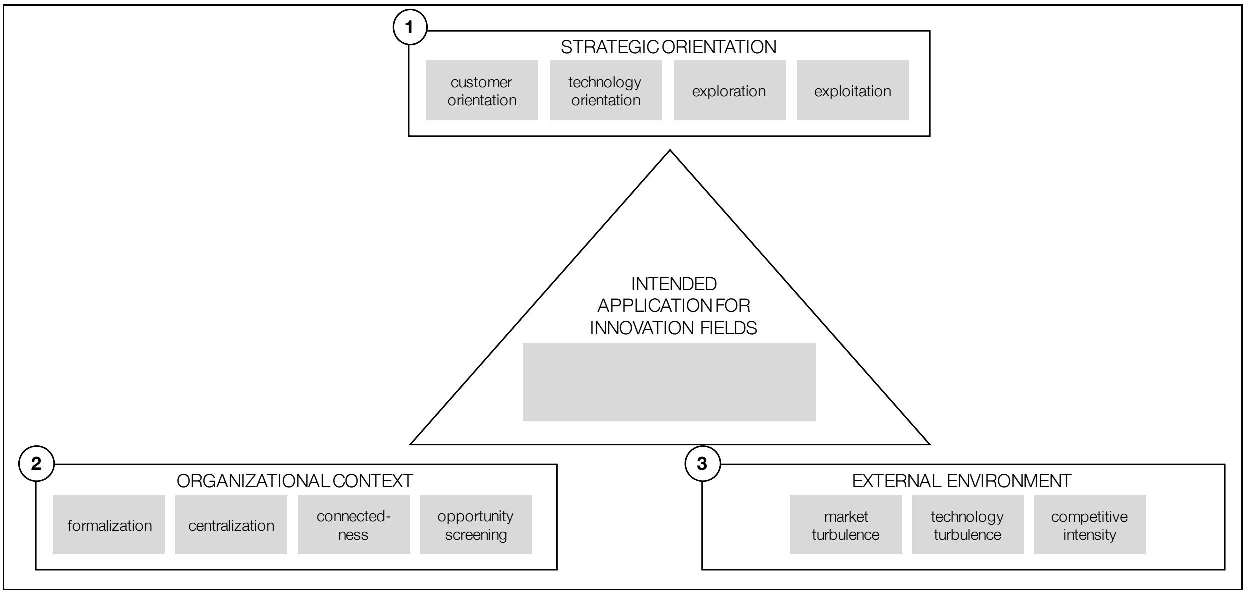


Figure 2: Research Framework Studying Intended Applications for Innovation Fields

Notes:
Source: own representation

On the base of the underlying empirical research, specific differences regarding perceived contextual factors and their influence on intended innovation field applications and perceived proficiency could be identified. Notably, factors regarding strategic orientation and external environment show the biggest impact on intended innovation field applications and perceived proficiency, while factors regarding the organizational context only play a minor role. Furthermore, the empirical findings substantiate the existence of different types of applications for innovation fields in the front-end of innovation.

Several theoretical contributions can be drawn from the thesis. First, this study gains insights into the role of perceived contextual factors and their influence on intended applications and perceived proficiency of innovation fields in a corporate context. Thereby, the dissertation derives a research framework that links perceived contextual factors and their influence on intended innovation field applications and perceived proficiency. Second, this dissertation delivers a comprehensive description of innovation field applications in the front-end of innovation. These findings contribute to and enhance the existing body of knowledge regarding innovation research, specifically regarding the front-end of innovation and innovation fields as well as organizational learning. Besides the advancement of scientific knowledge, managerial implications are drawn regarding the application of innovation fields in a corporate context.

1.3 Thesis Structure

After outlining the motivation, research focus and design of this thesis in Chapter 1, the theoretical framework is presented in Chapter 2, building the theoretical foundations of this dissertation. Chapter 2 introduces the notions of organizational learning and ambidexterity and derives the research framework (2.1), followed by the definition of innovation, its importance, and typologies (2.2), as well as the management of the front-end of innovation (2.3). Chapter 2.4 addresses innovation fields and their application in a corporate context, while Chapter 2.5 analyzes the research gap and derives the research questions. Chapter 3 compares different types of research (3.1), introduces mixed-methods (3.2) and case study research (3.3), followed by an explanation of the applied research design and case description (3.4). The qualitative study is conducted and its findings presented in Chapter 4. After addressing the data collection (4.1), the framework is introduced (4.2), and the data analysis is described (4.3). The findings of the qualitative study are presented in Chapter 4.4, divided into the different innovation field applications. The chapter closes with general conclusions (4.5), leading over to the quantitative study. The quantitative study is conducted and its findings presented in Chapter 5, starting with the description of the data collection (5.1), followed by the sample characteristics (5.2) and the explanation of measures (5.3). Subsequently, the data analysis is described (5.4), biases outlined (5.5) and the results are presented (5.6). Chapter 6 synthesizes the qualitative and quantitative findings and derives the propositions sorted by the type of application (6.1-6.2), followed by a discussion about the general findings (6.3). Chapter 7 delivers theoretical contributions (7.1), managerial implications (7.2), discusses limitations and future research (7.3), and concludes with an outlook (7.4). Figure 3 provides an overview of the structure of this thesis.

Chapter	Sections
Chapter 1: Introduction	1.1 Motivation 1.2 Research Focus 1.3 Thesis Structure
Chapter 2: Theoretical Framework	2.1 Organizational Learning and Ambidexterity 2.2 Innovation 2.3 Management of the Front-End of Innovation 2.4 Innovation Fields 2.5 Research Questions
Chapter 3: Methodology	3.1 Types of Research 3.2 Mixed-Methods 3.3 Case Study Research 3.4 Research Design Rationale
Chapter 4: Study 1 - Qualitative Study	4.1 Data Collection 4.2 Framework for Qualitative Study 4.3 Data Analysis 4.4 Results of Qualitative Study 4.5 General Conclusions of Qualitative Study
Chapter 5: Study 2 - Quantitative Study	5.1 Data Collection 5.2 Sample Description 5.3 Measures 5.4 Data Analysis 5.5 Biases 5.6 Results of Quantitative Study
Chapter 6: Discussion	6.1 Discussion of Innovation Field Applications 6.2 Discussion of Innovation Field Proficiency 6.3 Discussion of Overall Findings
Chapter 7: Conclusions	7.1 Theoretical Contributions 7.2 Managerial Implications 7.3Limitations and Future Research Directions 7.4 Outlook

Figure 3: Overview of Thesis Structure

Notes:
Source: own representation

2 Theoretical Framework

This chapter provides an overview of the current state of research regarding organizational learning and its link to innovation, innovation, the front-end of innovation and innovation fields, leading to the research questions underlying in this thesis.

First, the conceptual framework for this thesis – organizational learning – is introduced, followed by a description of its link to innovation and the notion of ambidexterity. Subsequently, the main contextual factors influencing ambidexterity are introduced, and a research framework is derived. Afterwards, important concepts are introduced, such as innovation, its importance and the introduction of innovation typologies and the innovation process. Thereafter, the front-end of innovation and its main phases are described. The outline of the main phases and the comparison of different management models of the front-end of innovation will show scholars' neglect of the strategic phase of the front-end of innovation. The importance of the strategic phase is outlined, as well as the ongoing debate around the formalization of the front-end of innovation, explicating the need for a more adaptive management approach in the front-end of innovation. In the following, innovation fields are introduced, an instrument to structure the strategic phase of the front-end of innovation by establishing guidelines that determine the search strategy, scope, depth, and locus of innovation search. The different applications of innovation fields are described and research gaps highlighted. After introducing the research questions of this thesis, the research framework outlines the main contextual factors influencing the application of innovation fields.

STRUCTURE OF CHAPTER 2: THEORETICAL FRAMEWORK

Figure 4: Chapter Overview of Theoretical Framework

Notes:
Source: own representation

2.1 Organizational Learning and Ambidexterity

The following chapter introduces the notion of organizational learning, its link to innovation and the notion ambidexterity in the context of innovation. Following this, the main contextual factors influencing ambidexterity are described.

2.1.1 History and Definition of Organizational Learning

The theory of **organizational learning** was first coined by Cyert and March (1963) in their book “A Behavioral Theory of the Firm” (Cyert & March, 1963). Organizational learning has gained increasing attention as a research topic since the publication of a follow-up article by James March (1991), called “Exploration and Exploitation in Organizational Learning" (March, 1991). Ever since, organizational learning has been applied to various research areas such as innovation, organizational adaption, strategic management and organization design (Raisch & Birkinshaw, 2008).

Organizational learning initially developed through the assumptions of behavioral studies of organizations. It is best described by a change of knowledge at the organizational level that is induced through experiences (Argote, Beckmann, & Epple, 1990, p. 1124). Experiences that organizations make or learn from others are translated into routines such as processes, strategies, and habits. Routines store knowledge and a change in routines in turn indicate a change in knowledge, which can be explicit, implicit or tacit. Organizational learning thus ensures the transfer of experiences and knowledge independent from the fluctuation of employees (Argote & Miron-Spektor, 2011, p. 1123; Levitt & March, 1988, p. 320). Changing routines is seen as a sign for occurred learning within the organization. (Argote et al., 1990, p. 1124; Levitt & March, 1988, p. 319). These changes in routines ultimately shape the decisions that organizations take. Therefore, organizational learning can also be described as the ability of an organization to generate, distribute, reflect and adopt its own experiences and experiences from their surroundings for judging and refining decisions (McKee, 1992, p. 233; Shrivastava & Grant, 1985, p. 98). There are some observations regarding what shapes these decisions. First, Levitt & March (1988) describe that organizations apply available policies rather than choosing which path to follow themselves. Secondly, they are more affected by past events and less by future expectations. Moreover, thirdly, organizational decisions are influenced by set goals and objectives (Levitt & March, 1988, p. 320).

As the capability to adapt to experiences, organizational learning is a success factor for the sustainable success of organizations (Argote & Miron-Spektor, 2011, p. 1123; Levitt & March, 1988, p. 336). This is particularly the case in the context of innovation (Alegre & Chiva, 2008, p. 323; Forrester, 2000, p. 43; Jiménez-Jiménez & Sanz-Valle, 2011, p. 414). The next chapter elaborates on the link between organizational learning and innovation and describes the underlying factor of why some organizations surpass others regarding learning.

2.1.2 Organizational Learning in the Context of Innovation

Several papers apply organizational learning to the innovation paradigm (Danneels, 2002; He & Wong, 2004; Jansen, Van Den Bosch, & Volberda, 2006; Raisch & Birkinshaw, 2008, p. 378). It is acknowledged that organizational learning is a success factor for innovation, as "an underlying variable explaining performance in strategic action" (McKee, 1992, p. 232; Normann, 1985, p. 221). For Benner and Tushman (2002), technological innovation is the root of organizational adaption (Benner & Tushman, 2002, p. 678). Furthermore, several papers show that organizational learning positively affects innovation performance (Alegre & Chiva, 2008, p. 323; Forrester, 2000, p. 43; Jiménez-Jiménez & Sanz-Valle, 2011, p. 414).

Concerning innovation, Levinthal and March (1981) present three distinct organizational learning characteristics, whereby organizations adapt their *search competencies*, *aspirations,* and *search strategies*. Search competencies address the efficiency of the search, while the aspirations can best be described with the organization's expectations towards the outcome of the search (Levinthal & March, 1981, p. 309). Especially regarding the connection between organizational learning and innovation, the aspect of search strategies for new product development[1] (NPD) is crucial for the renewal of the firm (Danneels, 2002, p. 1115). The renewal of the firm comprises expanding competencies, changing market fields, product offerings, structures and routines (Danneels, 2002, p. 1095; Teece, 2007, p. 1135).

There are two fundamental search strategies that organizations can follow: **exploration** and **exploitation** (Greve, 2007, p. 945; March, 1991, p. 71). As defined by March (1991), exploration is the search for new products and technologies, thereby enhancing the existing competencies of the organization. By contrast, exploitation involves the refinement and utilization of previously-acquired competencies (Greve, 2007, p. 945; March, 1991, p. 71). Exploration benefits are unclear, carry risks and are long-term-oriented, while exploitative benefits are more short-term-oriented and less risky (Greve, 2007, p. 945). As March (1991) puts it:

> "The story is told in many forms. Basic research has less certain outcomes, longer time horizons, and more diffuse effects than does product development. The search for new ideas, markets, or relations has less certain outcomes, longer time horizons, and more diffuse effects than does further development of existing ones." (March, 1991, p. 73)

Research links organizational learning and innovation by connecting the notions of the search strategies of exploration and exploitation to innovation typologies: so-called incremental innovation is linked to exploitation, which describes the combination and refinement of existing knowledge and technologies for existing customers and markets (Benner & Tushman, 2003, p. 243; Katila & Ahuja, 2002, p. 1191; March, 1991, p. 71). With exploitative innovation, existing products and distribution channels are improved, and processes and structures are strengthened (Abernathy & Clark, 1985, p. 5; Jansen et al., 2006, p. 1662).

On the other hand, radical innovation is linked to exploration, implying the search for entirely new solutions by building up new competencies. Thus, with radical innovation, new clients are catered, new market segments are entered, or new technologies are used, making radical innovation a multi-faceted concept (Benner & Tushman, 2003, p. 243; Katila & Ahuja, 2002, p. 1191; March, 1991, p. 71). Thus, radical innovation can be distinguished regarding building competency in markets, customers, sales channel, technologies or any combination of these (Benner & Tushman, 2003, p. 243; Danneels, 2002, p. 1108; Jansen et al., 2006, p. 1662). He and Wong (2004) describe explorative technological innovation projects for establishing new *product-market domains* (He & Wong, 2004, p. 484). Adapted from Danneels (2002),

Figure 5 shows the distinction regarding exploration and exploitation in terms of customer and technology.

[1] New product development encompasses all innovation activities leading from an initial idea to a commercialized offering on the market.

		Technology	
		Competence existing in firm	Competence new to firm
Customers	Competence existing in firm	Pure exploitation	Leveraging customer competence
	Competence new to firm	Leveraging technological competence	Pure exploration

Figure 5: Competence-Based New Product Matrix

Notes:
Source: Danneels, 2002, p. 1108

How an organization balances between exploration and exploitation is linked to prior organizational decisions and their perceived success. In this context, success is the connection between set goals and their achievement (Levitt & March, 1988, p. 325). Thus, as stated by Levinthal and March (1981), search strategies are adjusted according to failures and successes regarding the prior aspirations and goal achievements. This implies that successful search strategies are repeated while failed attempts are not (Levinthal & March, 1981, p. 310). This kind of behavior can lead to one-sided search strategies, focusing mainly on exploration or exploitation and organizations risk running into a competency trap with self-reinforcing decisions. However, organizations solely depending on exploration "are likely to find that they suffer the costs of experimentation without gaining many of the benefits" while excluding exploration leads to "suboptimal stable equilibria" (March, 1991, p. 71). Too much exploration might lead to below-average results due to its experimental character. A priority towards exploitation leads to overlooking new opportunities and inflexibility in times of environmental turbulence (Greve, 2007, p. 948; Katila & Ahuja, 2002, p. 1992).

Several studies show that the imbalance between exploration and exploitation has negative consequences for the performance of an organization (Greve, 2007, p. 945; Katila & Ahuja, 2002, p. 1192; Levinthal & March, 1993, p. 102). Conversely, balancing out exploration and exploitation leads to more success, shown through e.g., a patent study in the pharmaceutical industry (Kim, Song, & Nerkar, 2012, p. 1193), a study in the global robotics industry (Katila & Ahuja, 2002, p. 1191) or to sales growth shown in a study with 206 manufacturing firms (He & Wong, 2004, p. 484). Aside from organizations, Michelfelder and Kratzer (2013) show that balancing out exploration and exploitation in R&D collaborations exceed collaboration forms focusing on either one activity (Michelfelder & Kratzer, 2013, p. 1174).

The balance between exploitation and exploration is called **ambidexterity** (Tushman & O'Reilly, 1996), which is crucial for long-term survival (Levinthal & March, 1993), prosperity (March, 1991) and sustainable firm performance (Gibson & Birkinshaw, 2004, p. 212).

However, both of these activities require the allocation of resources, causing a trade-off between them (Greve, 2007, p. 945; Levinthal & March, 1993, p. 101). This trade-off is difficult to perform for companies due to the distinct characteristics of exploration and exploitation, making it less difficult to pursue one of them but the combination of both (Benner & Tushman, 2003, p. 245; Greve, 2007, p. 945; March, 1991, p. 72).

The next chapter outlines how organizations can reach the preferable balance between exploration and exploitation.

2.1.3 Reaching Ambidexterity

Reaching ambidexterity has been described as the goal for long-term survival, firm success and competitive advantage (March, 1991, p. 85). Literature addresses two ways to foster ambidexterity: (1) structural ambidexterity and (2) contextual[2] ambidexterity.

(1) **Structural ambidexterity** claims that only a structural division in organizational areas between exploitation and exploration will lead to ambidexterity (Jansen, Tempelaar, van den Bosch, & Volberda, 2009; Lee, Woo, & Joshi, 2016, p. 2; Tushman & O'Reilly, 1996)
(2) **Contextual ambidexterity** claims that contextual factors foster reaching ambidexterity (Gibson & Birkinshaw, 2004; Lee et al., 2017, p. 3; Raisch & Birkinshaw, 2008)

Gibson and Birkinshaw (2004) describe contextual ambidexterity as "the behavioural capacity to simultaneously demonstrate alignment and adaptability across an entire business unit" (Gibson & Birkinshaw, 2004, p. 209). They argue that ambidexterity is best built through practices, policies and contextual factors that influence the individual behavior in favor of a balance between alignment and adaptability (Gibson & Birkinshaw, 2004, p. 210). In order to reach contextual ambidexterity, it is suggested that the top management creates a surrounding in which the individuals have the freedom to split their time between exploitative and explorative innovation activities autonomously, thus placing the decision into the hands of the employees rather than the top management. This implies that employees are flexible and that their skill-set is generalistic (J. Birkinshaw & Gibson, 2004, p. 50).

Tushman and O'Reilly (1996) define structural ambidexterity as "ability to simultaneously pursue both incremental and discontinuous innovation and change" (Tushman & O'Reilly, 1996, p. 24). In contrast to Gibson and Birkinshaw (2004), they perceive that ambidexterity can only be reached through organizational divergence and separation (Tushman & O'Reilly, 1996, p. 25). In this case, both activities are strictly separated in different units, and top management decides on the ratio between exploration and exploitation while laying out the structure for these activities. This indicates the need for more specialized personnel (J. Birkinshaw & Gibson, 2004, p. 50).

[2] Contextual ambidexterity is also described as organizational ambidexterity. Both terms are tantamount, and the term contextual ambidexterity will be used in the following.

The next table sums up the differences between structural and contextual ambidexterity.

	Structural ambidexterity	**Contextual ambidexterity**
Reaching ambidexterity	Explorative and exploitative activities are performed in different departments or units	Employees decide on pursuing explorative or exploitative activities
Decision between exploitation and exploration	Top management	Employees
Responsibility of upper management	Set-up of structure for division of exploration and exploitation	Create context that enables employees to perform either explorative or exploitative activities
Type of capability required for employees	Specialized	Generalistic

Table 1: Differences Between Structural and Contextual Ambidexterity

Notes:
Source: J. Birkinshaw & Gibson, 2004, p. 50

Birkinshaw and Gibson (2004) state that structural and contextual ambidexterity cannot be separated entirely: rather, they have to be seen as complementing each other (J. Birkinshaw & Gibson, 2004, p. 54). Several studies support the notion of contextual ambidexterity as more long-term-oriented, such as Jansen et al. (2006) for large organizations and Chang and Hughes (2012) for small- and medium-sized companies (Chang & Hughes, 2012, p. 12; Jansen et al., 2006, p. 1670). By establishing a favorable context for both exploration and exploitation within the organization rather than a single unit, the whole organization can adapt and feel responsible for the present and future success (Gibson & Birkinshaw, 2004, p. 211). Thus, this dissertation will focus on contextual ambidexterity.

As outlined, ambidexterity is described as one of the main factors in reaching sustainable success, outperforming organizations that concentrate on either exploration or exploitation. However, it is important to understand the contextual factors that influence contextual ambidexterity (Argote & Miron-Spektor, 2011, p. 1123).

2.1.4 Influencing Factors for Ambidexterity

Several papers reveal factors influencing ambidexterity (Argote & Miron-Spektor, 2011, p. 1125; Jansen et al., 2006, p. 1664; McKee, 1992, p. 233; Raisch & Birkinshaw, 2008, p. 381; Raisch, Birkinshaw, Probst, & Tushman, 2009, p. 685; Tushman & O'Reilly, 1996, p. 11).

McKee (1992) cites factors such as the organizational culture, strategy, structure, and environment (McKee, 1992, p. 233). Tushman and O'Reilly (1996) define four pillars that need to change in order to become an ambidextrous organization: strategy, structure, people, and culture (Tushman & O'Reilly, 1996, p. 11).

Jansen et al. (2006) use formal and informal organizational coordination mechanisms such as formalization, centralization or connectedness, as well as environmental influencing factors like competitive intensity (Jansen et al., 2006, p. 1664). Gibson and Birkinshaw (2004) identify contextual factors such as discipline (as in formalization), stretch (as in expectation management), trust (as in centralization) as well as the leadership attribute support (Gibson & Birkinshaw, 2004, p. 213). In a comprehensive study, Raisch and Birkinshaw (2008) present a framework outlining the influencing factors of contextual ambidexterity, using environmental factors such as environmental or competitive dynamism, organizational antecedents such as structure, context and leadership and other moderators such as strategic orientation (Raisch & Birkinshaw, 2008, p. 381).

Raisch et al. (2009) use a framework, incorporating different tensions to balance exploration and exploitation such as individual or organizational factors and internal or external factors (Raisch et al., 2009, p. 685). Argote and Miron-Spektor (2011) develop a framework for organizational learning, declaring the environmental context as one of the themes influencing organizational learning. The environmental context comprises "characteristics of the organization, such as its structure, culture, technology, identity, memory, goals, incentives, and strategy. The context also includes relationships with other organizations through alliances, joint ventures, and memberships in associations" (Argote & Miron-Spektor, 2011, p. 1125).

The following table summarizes the main influencing factors drawn from framework studies, assigned according to broader themes.

Authors	Strategic orientation	Organizational context	External environment	Structure	Other factors
McKee (1992)	X	X	X	X	
Tushman & O'Reilly (1996)	X	X		X	• People
Gibson & Birkinshaw (2004)		X			• Support
Jansen, van den Bosch & Volberda (2006)		X	X		
Raisch & Birkinshaw (2008)	X	X	X	X	• Leadership
Raisch, Birkinshaw, Probst & Tushman (2009)		X	X		• Informal network • Leadership
Argote & Miron-Spektor (2011)	X	X	X	X	• Technological identity • Memory • Goals

Table 2: Overview of Influencing Factors in Ambidexterity Studies

Notes:
Source: own representation

Strategic orientation is described as the organization's strategic positioning to generate aligned behavior and prioritization regarding either the customer (market)[3], competitors or technology (Gatignon & Xuereb, 1997, p. 78). Organizational context refers to "the systems, processes, and beliefs that shape individual-

[3] Market and customer orientation are understood as tantamount terms and they describe long-term oriented and pro-active behavior to gather all relevant information on customers including latent needs to provide superior value to customer (Slater & Narver, 1998, p. 1004). Although market orientation is sometimes described as comprising both the customer and competitor orientation (Narver & Slater, 1990, p. 21), the underlying thesis understands market orientation as being focused on the customer.

level behaviors in an organization" (Gibson & Birkinshaw, 2004, p. 212; Raisch & Birkinshaw, 2008, p. 391). The external environment describes the external complexity and uncertainty towards, e.g. the market, technology, and competitors (Tidd, 2001, p. 175). As outlined above, the underlying dissertation analyzes contextual factors. Consequently, structural factors will be omitted from further investigation.

Therefore, this dissertation will focus on the (1) strategic orientation, (2) organizational context and (3) external environment as contextual factors influencing ambidexterity. These will be elaborated in further detail in the following chapters.

2.1.4.1 Strategic Orientation

As outlined by Posen and Levinthal (2012), strategies mirror the way in which organizations understand the world (Posen & Levinthal, 2012, p. 598). In the context of building ambidexterity, this manifests in strategic orientation and the choice of search strategies.

Market orientation is one characteristic of strategic orientation, defined as the organization's capacity to process and react to customer information gathered (Kohli & Jaworski, 1990; Narver & Slater, 1990). In a study in the food industry, Kyriakopoulos and Moorman (2004) show that market orientation has a positive effect on ambidextrous marketing strategies. Organizations that are ambidextrous without market orientation show a decrease in financial achievement (Kyriakopoulos & Moorman, 2004, p. 233). Atuahene-Gima (2005) provides evidence that market orientation (in this case measured through orientation towards customers and competitors) positively influences resource allocation to exploitative and explorative innovation projects (Atuahene-Gima, 1995, p. 284; Raisch & Birkinshaw, 2008, p. 395).

Baker and Sinkula (2007) and Wei (2014) analyze whether market orientation influences ambidexterity. Baker and Sinkula (2007) ascertain that with higher market orientation, the balance between incremental and radical innovation improves and *customer-led approaches* (incremental innovation in response to customers' immediate reactions and needs) are not over-prioritized (Baker & Sinkula, 2007, p. 329). In a study with Chinese companies, Wei (2014) finds that the strategic choice of proactive or responsive market orientation does make a difference towards ambidexterity: "We find that the interaction of exploitation and exploration has a negative effect on firm performance in a firm with responsive market orientation whereas it has a positive effect on firm performance in a firm with proactive market orientation" (Z. Wei, Zhao, & Zhang, 2014, p. 150). Thus, the proactive and long-term orientation towards customers positively influences ambidexterity.

A study by Zhou, Yim, and Tse (2005) shows that organizational learning is positively influenced by technology orientation and in turn positively influences technology-based radical innovation (K. Z. Zhou, Yim, & Tse, 2005, p. 54). Technology orientation is understood as the focus of organizations on the usage of new and state-of-the-art technologies for product development. Furthermore, this orientation indicates that the company has strong capabilities to utilize existing technological knowledge to develop new solutions, ultimately responding to the needs of customers (Gatignon & Xuereb, 1997, p. 78; K. Z. Zhou et al., 2005, p.

45). By studying Chinese companies, the study by Zhou et al. (2005) highlights that technology orientation increases knowledge-learning behavior and in turn enhances organizational learning, ultimately leading to a higher probability to develop technology-based radical innovations (K. Z. Zhou et al., 2005, p. 46).

Taylor and Greve (2006) highlight that the set search strategy determining a focus on exploration or exploitation has a greater impact than the diverse backgrounds and the formation of the NPD teams (Greve, 2007, p. 949; Taylor & Greve, 2016, p. 736). If firm performance drops to a certain low, strategic re-alignment sets in, leading to the so-called problemistic search. Problemistic search is defined as the strategic decision to focus on either more exploration or exploitation (Greve, 2007, p. 950; Levinthal & March, 1981, p. 308).

> "The findings of this study suggest that reductions in performance significantly increased the rate of making exploration innovations as well as that of exploitation innovations, and at the same time. Managers solving problems do turn to exploitation as a solution, but also try exploration. Problemistic search thus offers an explanation for why organizations that usually exploit will sometimes try exploration." (Greve, 2007, p. 968)

Problemistic search determines search boundaries given through the current strategic orientation. Thus, problemistic search influences the balance between exploration and exploitation and thereby increases or reduces the risks that are taken (Greve, 2007, p. 950). It is important to note that the concept of problemistic search needs to be differentiated from the overall goal of organizations to become ambidextrous. Problemistic search equals a temporary strategic orientation at a given time to focus on either explorative or exploitative innovation activities.

Thus, in ambidexterity research, several papers outline the influence of strategic orientation, such as market (customer) orientation, technology orientation, and problemistic search.

2.1.4.2 Organizational Context

Several studies have examined the impact of organizational factors towards ambidexterity and name success factors to achieve a balance between exploration and exploitation.

Gibson and Birkinshaw (2004) conduct research on the attributes of discipline, stretch, support and trust in their study, identifying these as success factors for ambidextrous organizations (Gibson & Birkinshaw, 2004, p. 213). They form two contexts out of these four variables – namely the performance measurement context and social context – that influence ambidexterity (Gibson & Birkinshaw, 2004, p. 217). The performance management context is defined as the balance between formalization and freedom in work, while the social context can be understood as connectedness and collaboration.

Tushman and O'Reilly (1996) identify mutual vision, flexibility, open-mindedness and culture as factors that support ambidexterity (Tushman & O'Reilly, 1996, p. 26). Furthermore, they see leadership characteristics, such as leadership support, adaptable managers, and aligned top management as being favorable for ambidexterity (O'Reilly & Tushman, 2008, p. 187; Tushman & O'Reilly, 1996, p. 26).

Keupp et al. (2013) analyze that the internal organization (routines, communication, information flows) of a company affects the conditions for strategic choices, which also implies the choice between exploration and exploitation (Keupp et al., 2013, p. 379). Alegre and Chiva (2008) argue that decentralized decision-making and social connectedness influence innovation outcomes in the context of organizational learning (Alegre & Chiva, 2008, p. 316).

Levinthal and March (1981) highlight that slack resources positively influence the amount of exploration in an organization (Levinthal & March, 1981, p. 309). Slack resources are defined as overstock in resources that can be used in the search for ideas, which is not guided thematically but influenced through serendipity and personal interests in certain topics (Cyert & March, 1963, p. 279). Consequently, slack resources foster explorative innovation. The amount of slack research is determined by the degree of performance monitoring and hence the level of formalization (Greve, 2007, p. 951; Levinthal & March, 1981, p. 309). On the other hand, it can be argued that the amount of slack resources is also influenced by managerial traits such as risk-taking and problem-solving mechanisms. Thus, these characteristics can predict the balance between exploration and exploitation (Greve, 2007, p. 969).

March (1991) claims that the balance between exploration and exploitation is dependent on organizational policies and practices, which is tantamount to the degree of formalization that can be found in organizations (March, 1991, p. 71). Jansen et al. (2006) empirically test the influence of formalization on ambidexterity, showing that formalization intensifies exploitative endeavors, while it does not reduce explorative innovation (Jansen et al., 2006, p. 1668).

Related to formalization is centralization, which is said to shut down explorative innovation projects (Greve, 2007, p. 951). Jansen et al. (2006) support this hypothesis by showing that centralization reduces the number of explorative projects (Jansen et al., 2006, p. 1668).

Regarding connectedness – defined as the possibility for informal talk and the availability of knowledge – Jansen et al. (2006) reveal a positive relationship towards explorative and exploitative innovation, although an inverse U-shaped relation was expected. Thus, connectedness is seen as favorable for ambidextrous innovation (Jansen et al., 2006, p. 1668). The paper even highlights that dense social relations weigh more strongly than formalization and centralization (Jansen et al., 2006, p. 1670).

Lee (2016) shows that a pro-innovation culture is a positive influencing factor for ambidexterity, but it can also stress exploration to the point that it negatively influences innovation performance (Lee, 2016, p.10).

Calantone et al. (2002) emphasize a learning orientation for ambidexterity, comprising a mutual vision, open-mindedness and knowledge sharing (Calantone, Cavusgil, & Zhao, 2002, p. 516), while Alegre and Chiva (2008) define certain capabilities that lead to ambidexterity, such as risk tendency, internal and external connectedness and joint decision-making (Alegre & Chiva, 2008, p. 319).

It can be noted that the main organizational factors influencing ambidexterity are formalization, centralization, and connectedness.

2.1.4.3 External Environment

March (1991) states that the balance between exploration and exploitation is very sensitive to changes in the environment, particularly regarding environmental turbulence and competitiveness (March, 1991, p. 81). Levinthal and March (1993) show that the majority of organizations would be successful, in the case of environmental stability. They indicate that environmental uncertainty and exogenous changes moderate the effect of exploration and exploitation on performance (Levinthal & March, 1981, p. 319).

In their comprehensive literature review, Raisch and Birkenshaw (2008) highlight that external factors such as dynamism and competitiveness can (1) demand companies to act ambidextrously and (2) be a boundary condition for ambidextrous organizations (Raisch & Birkinshaw, 2008, p. 394).

A study by Jansen et al. (2005) tests the effects of environmental factors on innovation ambidexterity. They show that the "extent to which units pursue both types of innovations simultaneously is shaped by local environmental conditions and organizational characteristics" (Jansen, Van Den Bosch, & Volberda, 2005, p. 352). A highly dynamic environment and strong competitiveness lead to companies focusing on both explorative and exploitative innovation projects.

In a different study by Jansen et al. (2006), it is shown that environmental dynamism moderates ambidexterity. In the case of high environmental dynamics, explorative innovation leads to improved financial performance. On the other hand, there is a negative relationship between financial performance and exploration when there is no environmental turbulence. A consistent negative relationship could be detected in the case of exploitation and dynamic environments (Jansen et al., 2006, p. 1668f.).

Auh and Menguc (2005) test the influence of competitiveness on exploration and exploitation in accordance with the strategy type of the company (prospector or defender) (Auh & Menguc, 2005, p. 1652). Prospectors[4] are more prone to exploration, while defenders mainly rely on exploitation (Auh & Menguc, 2005, p. 1654; R. E. Miles, Snow, Meyer, & Coleman, 1978 p.151). In a study with Australian companies, they ascertain that both exploration and exploitation have an impact on firm performance. Furthermore, they show that regardless of the strategy type, exploration has a more positive impact on effective firm performance than exploitation (Auh & Menguc, 2005, p. 1660). In times of high competitiveness, exploitation has

[4] Miles and Snow (1978) develop a strategy typology for organizations, distinguishing between four different types. **Defenders** want to maintain stability by only offering a limited number of products, whereby the goal is to conserve a proportion of the market. They have no intention to innovate beyond their market-domain. **Prospectors** are the opposite of defenders by proactively using new market opportunities when they arise. They want to be perceived as innovation leader and are willing to take risks. **Analyzers** pursue a hybrid strategy by combining elements of the defender and prospector. Depending on the opportunity, they strive for cost leadership or for innovation leadership. The principle behind is profit maximization by the concurrent reduction of risk. Finally, whereas all prior typologies describe proactive forms of organizations, **Reactors** do not possess a consistent mechanism to react to external changes, thus leading to constant instability (R. E. Miles et al., 1978).

a positive impact on efficient firm performance for prospectors (explorative companies). Conversely, for defenders (exploitative companies), more exploitation is negatively linked to efficient firm performance under high competitiveness. Overall, the authors imply that the balance between exploration and exploitation is also valid in times of high levels of competitiveness (Auh & Menguc, 2005, p. 1660). It can be noted that the main environmental factors comprise market uncertainty, dynamism, turbulence and competitiveness and the findings of the studies are ambiguous.

Outlining the main contextual factors influencing ambidexterity does not answer the question concerning what measures can be taken to foster reaching contextual ambidexterity. In a paper by Wei, Yi and Guo (2014), it is argued that previous research does not offer an answer concerning how organizations can dynamically adapt their resource portfolios to reach ambidexterity (Z. Wei, Yi, et al., 2014, p. 833). Several other papers also outline the neglect of described solutions for corporations to build up ambidexterity (Cantarello et al., 2012, p. 45; Judge & Blocker, 2008, p. 922) Thus, the next chapters first introduce important concepts such as innovation and the front-end of innovation, followed by the introduction of innovation fields as an instrument that structures the front-end of innovation and to foster ambidexterity.

Conclusion

- Organizational learning shapes decision-making through the conversion of experiences into routines and habits.
- Organizational learning is a success factor for innovation by fostering organizational adaption.
- Two main search strategies are distinguished: exploration and exploitation. Exploration comprises the search for new products or the use of new technologies and is linked to radical innovation, while exploitation comprises the refinement of existing competencies and is linked to incremental innovation.
- A balance between exploration and exploitation – so-called ambidexterity – is favorable for long-term success.
- Two types of ambidexterity can be distinguished: while contextual ambidexterity pursues exploitation and exploration simultaneously within the organization, structural ambidexterity is reached through the structural division of tasks in different units.
- Contextual ambidexterity is seen as the more sustainable concept for long-term success and three main influencing factors are described: strategic orientation, organizational context, and external environment.

2.2 Innovation

This chapter introduces the definition of innovation, the importance of innovation as well as innovation typologies and the management of innovation.

2.2.1 Definition of Innovation and Invention

The concept of **innovation** was first introduced by Schumpeter in 1934, defined as “carrying out new combinations” (Schumpeter, 1934, p. 66) or “doing things differently” (Schumpeter, 1939, p. 80). According to Dosi (1988) and Nelson and Winter (1982), innovation comprises the solving of problems that are not clearly structured (Dosi, 1988, p. 1125; Nelson & Winter, 1982). With the recombination of existing knowledge, a solution to the problem and new knowledge – thus, innovation – is created (Nelson & Winter, 1982, p. 130). From a firm's perspective, innovation is oriented towards commercialization on the market (Colarelli O'Connor, Leifer, Paulson, & Peters, 2008, p. xxii; Rogers, 2003, p. 12). It is important to note that although innovation implies the introduction of something new in the marketplace, this can also be simply the perception of something new by single entities. Innovation is a multi-faceted concept and can comprise the implementation of new or improved products, services, technologies, the entry in or creation of new markets or marketing techniques (Gartner, 1990, p. 25; OECD - Statistical Office of the European Communities, 2005, p. 46).

Schumpeter (1939) differentiates innovation from **invention**: "[i]nnovation is possible without anything we should identify as invention and invention does not necessarily induce innovation, but produces of itself no economically relevant effect at all" (Schumpeter, 1939, p. 80). An invention represents a discovery of new things, such as an "object, process or technique" (Colarelli O'Connor et al., 2008, p. xxii), but it does not translate into an economic surplus for the organization (Garcia & Calantone, 2002, p. 112). The creation of inventions can either be a mere coincidence, or can be enforced by a specific business context: for example, dedicated resources or competitive intensity on the market (Schumpeter, 1939, p. 82). Chronologically, an invention is discovered first and possibly commercialized as an offer on the market, which makes it an innovation (Garcia & Calantone, 2002, p. 112). Thus, the difference between invention and innovation is that while both concepts entail the creation of something new, an invention does not automatically address a customer need or a market opportunity, while innovation imples something new that is marketable (Green, Gavin, & Aiman-Smith, 1995, p. 205).

For the purpose of this thesis, innovation will be adopted from the OCED Oslo Manual as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method […]" (OECD - Statistical Office of the European Communities, 2005, p. 46). In this context, Innovation has the goal of being commercialized, thereby bringing an economic surplus to the organization, regardless of whether it will actually be launched or successfully implemented. Therefore, R&D projects handed over to serial development with the intention of being commercialized are considered as innovation.

2.2.2 Importance of Innovation

Drucker (1955) stated that innovation is an integral part of an organization: "because the purpose of business is to create a customer, the business enterprise has two – and only two – basic functions: marketing and innovation" (Drucker, 1955, p. 32). This notion still holds true today, and companies without innovation are difficult to find. Innovation is one of the main drivers of growth, sustainable success and competitive advantage (Legnick-Hall, 1992, p. 406; Rosenkopf & Nerkar, 2001, p. 287; Tidd, 2001, p. 170f.; Weerawardena, 2003, p. 26). Legnick-Hall (1992) defines four dimensions that explain the path from innovation and competitive advantage: first, innovations that cannot be easily replicated pose sustainable benefit. Second, if innovations address user needs and market demands and raise desirability, they are more likely to lead to competitive advantages. Third, the timing of innovation is favorable for sustained success, which implies, being the first on the market and capturing a market premium and valuable insights prior to the competition. Finally, available competencies and technologies foster competitive advantage through quick exploitation and improvement of innovations in the marketplace (Legnick-Hall, 1992, p. 400ff.). Putting all of these dimensions together paves the way for organizations to remain competitive and it illuminates the importance of innovation for long-term success.

According to a survey by BCG regarding the state of innovation, conducted globally and annually, “79% of respondents ranked innovation as a top-three priority at their company [...] the highest percentage since we began asking the question in 2005” (Ringel et al., 2015, p. 3). Renowned newspapers such as Forbes and FastCompany nominate the most innovative companies each year, granting innovative companies and the topic of innovation even further attention and media exposure (Dyer & Gregersen, 2015; Fast Company, 2016; Forbes, 2016).

2.2.3 Typology of Innovation

The OECD Oslo Manual distinguishes between four main types of innovation: product innovations, process innovations, marketing innovations and organizational innovations (OECD - Statistical Office of the European Communities, 2005, p. 47). Additionally, business model innovation is added as the fifth type of innovation due to increasing research attention and the growing importance of achieving competitive advantage (Gassmann, Frankenberger, & Csik, 2014, p. 90; M. W. Johnson, Christensen, & Kagermann, 2008, p. 52). The following table introduces the different types of innovation.

Type of innovation	Description	Characteristics
Product innovation (OECD - Statistical Office of the European Communities, 2005, p. 48)	Comprises goods and services	Considerable changes in technical requirements, parts and materials, software, customer experience and other utilitarian features
Process innovation (OECD - Statistical Office of the European Communities, 2005, p. 49)	Comprises manufacturing and delivery methods	Considerable change in approach, operation, appliances, or programming
Marketing innovation (OECD - Statistical Office of the European Communities, 2005, p. 49)	Comprises new methods of marketing, including packaging, price, promotion, and place	Considerable changes in design, type of packaging, new sales channels, new types of promotion efforts and pricing strategies for enhancing customer needs
Organizational innovation (OECD - Statistical Office of the European Communities, 2005, p. 50)	Comprises changes in organizational methods, such as business policies, practices, workplace, and external relations	Considerable changes in organizational routines, structural changes in organizational setups and business activities and external collaborations, mostly done for efficiency reasons, such as to decrease administration costs
Business model innovation	Comprises the value creation, delivery and capture of main business activities (Osterwald & Pigneur, 2010, p. 14)	Considerable changes in the value proposition, revenue model, value chain, and target group (Gassmann et al., 2014, p. 91)

Table 3: Overview of Types of Innovation

Notes:
Source: OECD - Statistical Office of the European Communities, 2005, p. 49

The underlying dissertation will focus on product innovation since the innovation management might differ when taking other innovation types into account.

There is one additional type of innovation that needs to be distinguished from the typologies described above, namely the research project. Research projects are the precursor to innovation projects, and they are established to gather and build knowledge in a specific domain that is crucial for product development. These projects are often technology-oriented, explorative and riskier than innovation projects (Clark & Wheelwright, 1997, p. 74). Furthermore, these projects lack routines, making them distinct from other types of innovation projects, being difficult to measure and control and best comparable to radical innovation projects (Abernethy & Brownell, 1997, p. 233). They can also be set up as strategic initiatives without an actual market pull. The deliverable of these projects comprises either a proof of concept or the concept itself, rather than a product ready to be launched (Nobelius & Trygg, 2002, p. 335). The results of research projects are integrated into innovation projects.

2.2.4 Definition of Innovativeness

After describing the distinction between innovation and invention, outlining the importance of innovation and its typologies, the term **innovativeness** will be addressed. Product innovativeness has been shown to affect firm success[5] in various studies (Calantone, Chan, & Cui, 2006, p. 417; Cho & Pucik, 2005, p. 569; Kleinschmidt & Cooper, 1991, p. 250).

According to Garcia (2002), innovativeness measures the degree of novelty of innovation. High product novelty refers to a high level of innovativeness (Garcia & Calantone, 2002, p. 112). Daneels and Kleinschmidt (2001) distinguish between the customer and firm perspective and the concepts of fit and familiarity, making innovativeness a multi-dimensional phenomenon (Danneels & Kleinschmidt, 2001, p. 361; Salomo, Gemünden, & Leifer, 2007, p. 2). Fit to technological and marketing resources as well as familiarity with the technological and market environment at the firm level are the distinguishing factors of very innovative versus less innovative projects and products. For Garcia and Calantone (2002), fit not only refers to resources but to knowledge available in the market and technology domain (Garcia & Calantone, 2002, p. 124). The following figure shows the gradient of innovativeness from the firm's perspective according to fit and familiarity.

[5] Measured through growth, profitability and premium market value (Cho & Pucik, 2005, p. 569), product advantage and product profitability (Calantone et al., 2006, p. 417) and product performance (Kleinschmidt & Cooper, 1991, p. 250)

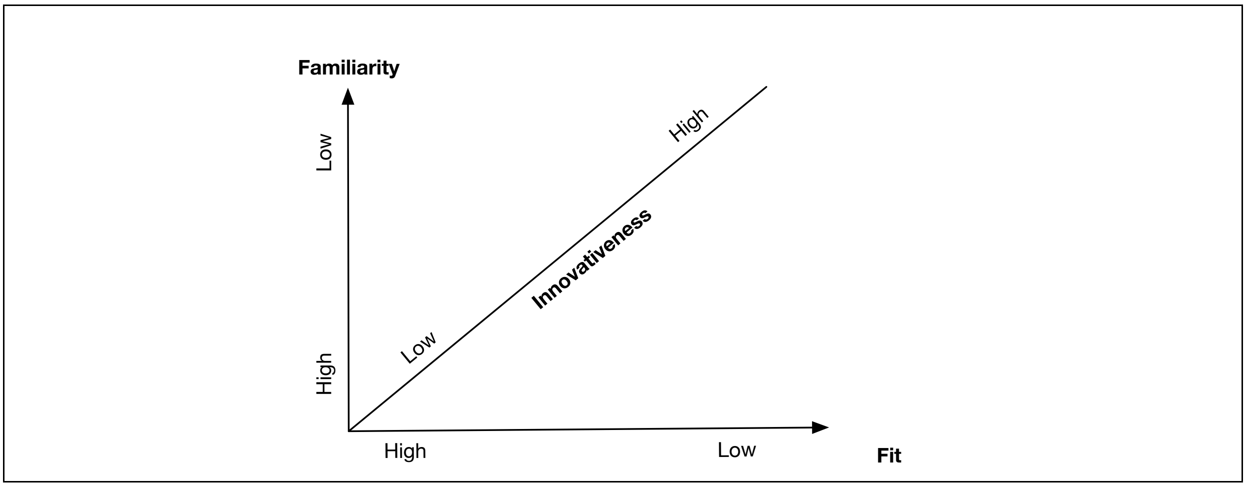


Figure 6: Fit- and Familiarity Paradigm for Innovativeness

Notes:
Source: Danneels & Kleinschmidt, 2001, p. 361

It might be arguable, whether low familiarity does necessarily correspond to high innovativeness. From an organization's perspective, when starting an innovation activity with low familiarity, the organization assumes high innovativeness. Resources would not have been allocated if the activity did not project substantial benefits and added value.

A different approach to the innovativeness typology is proposed by Henderson and Clark (1990) using the dimension of (1) the impact of innovation on the core concepts of the firm and (2) its impact on the linkage of components. This results in four different kinds of innovations, shown in

Figure 7 (Henderson & Clark, 1990, p. 11).

		Core concepts	
		Reinforced	Overturned
Linkage between core concepts and components	Unchanged	Incremental innovation	Modular innovation
	Changed	Architectural innovation	Radical innovation

Figure 7: Innovativeness Typology from Henderson and Clark (1990)

Notes:
Source: Henderson & Clark, 1990, p. 12

This typology introduces incremental and radical innovation as the extremes of a spectrum. Combined with the typology of Danneels and Kleinschmidt (2001), low innovativeness translates into incremental innovation projects, while high innovativeness refers to radical or discontinuous innovation projects. Incremental innovation can be defined as "products that provide new features, benefits, or improvements to the existing technology in the existing market", while radical innovations "embody a new technology that results in a new market infrastructure" that "advance the price/performance frontier by much more than the existing rate of progress" (Garcia & Calantone, 2002, p. 120ff.; Gatignon, Tushman, Smith, & Anderson, 2002, p. 1107). Leifer, McDermott, and Colarelli O'Connor (2000) agreed on the following definition: "[a] radical innovation project is one with the potential to produce [...] an entirely new set of performance features; improvements in known performance features of five times or greater; or a significant (30 percent or greater) reduction in cost" (Leifer, McDermott, & Colarelli O'Connor, 2000, p. 5). Radical innovation projects usually are accompanied by a high technological unpredictability, a lack of experience in the technological and business domain and higher costs and risks than incremental innovation (Colarelli O'Connor & Ayers, 2005, p. 24; Green et al., 1995, p. 205). This distinction complies with the terms of exploitation and exploration introduced in Chapter 2.1.2.

However, the mere distinction between radical and incremental innovation is short-sighted. Rather, this differentiation needs to be seen as extremes of a spectrum. Therefore, several frameworks have been established that describe innovation typologies (Garcia & Calantone, 2002; Henderson & Clark, 1990; Wheelwright & Clark, 1992).

For example, Garcia and Calantone (2002) offer a more granulated framework with incremental, truly new and radical innovations. These are differentiated through the axis of market and technology disruptions that they create at the macro and micro level (Garcia & Calantone, 2002, p. 119f.). The macro level comprises novelty to the world, market or industry while the micro level incorporates novelty to customers or the company (Garcia & Calantone, 2002, p. 120; Mishra, Kim, & Lee, 1996, p. 532; Schmitdt & Calantone, 1998, p. 116). Therefore, radical innovations generate disruptions at both the macro and micro level, while incremental innovations only disrupt at the micro level (Garcia & Calantone, 2002, p. 123). The underlying thesis will follow the distinction of innovativeness being influenced by the market and technological disruption at the micro and macro level.

Having established the importance of innovation for organizations, it needs to be noted that "[a] highly innovative product does not automatically imply a highly innovative firm" (Garcia & Calantone, 2002, p. 117). Firm innovativeness – as the "propensity for a firm to innovate or develop new products" (Damanpour, 1991, p. 556; Garcia & Calantone, 2002, p. 113) – has to be considered from a different perspective, namely in dependence on the organization of innovation activities and the effectiveness of their execution.

2.2.5 Management of Innovation

Independent from the degree of innovativeness, the question emerges concerning whether and how innovation is managed in organizations. Drucker (1985) analyzed that "[i]n business, innovation rarely springs from a flash of inspiration. It arises from a cold-eyed analysis […]" (Drucker, 1985, p. 67). Thus, for quite some time, practitioners and researchers alike have been exploring ways to manage innovation (Colarelli O'Connor & Ayers, 2005; Colarelli O'Connor et al., 2008; Cooper, 1983, 1988, 2005; Cooper et al., 2004; Cooper & Kleinschmidt, 1991, 1994, 2001; Lynn, Morone, & Paulson, 1996). There are several innovation management models facilitating the creation and planning of innovation. They involve all tasks to transform an idea into a marketable offer such as products or services (D. Smith, 2006, p. 106). The dominant innovation management model is the so-called *stage-gate process* (Cooper, 1988, 2005; Cooper et al., 2004; Cooper & Kleinschmidt, 1986, 1991, 1994, 2001). It was first designed in 1983 and is used by 80% of corporations (Adams-Bigelow, 2004, p. 549). This management model contains five to seven so-called *stages* and their respective *gates* (Cooper, 1983, p. 7) and it has since been modified and further developed (Cooper, 2008; Cooper, Edgett, & Kleinschmidt, 2002; Cooper & Kleinschmidt, 2001; Ettlie & Elsenbach, 2007). Cooper (2008) describes the stage-gate process as a “conceptual and operational map for moving new product projects from idea to launch and beyond – a blueprint for managing the new product development (NPD) process to improve effectiveness and efficiency” (Cooper, 2008, p. 214). In each stage, the dedicated team for the innovation project gathers and analyzes information to enable and facilitate a decision at the gate to end or further pursue the project (Cooper, 2008, p. 214). Figure 8 shows an exemplary overview of the stage-gate process.

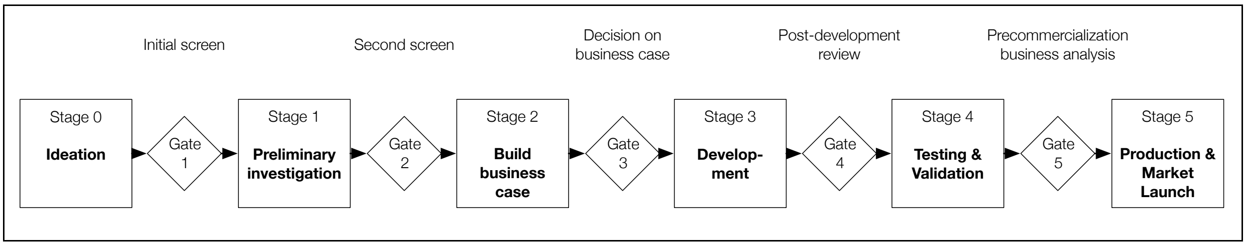


Figure 8: Overview of the Stage-Gate Process

Notes:
Source: Cooper, 2001

The first three stages comprise an ideation phase – also called *discovery* – namely the *preliminary investigation*, covering technical and market evaluation of the idea, and the stage of *building a business case*, where the idea is investigated in detail through competitor and in-depth technical analysis as well as regarding its overall attractiveness and alignment with customer needs. The following *development* phase is linked with large resource allocation and the development of a prototype, which is tested and validated in the subsequent stage. Stage 5 comprises the start of production and the market launch of the product followed by a *post implementation review* assessing the project performance (Cooper & Kleinschmidt, 2001, p. 7f.).

It is said that the stage-gate process is more appropriate for incremental innovation and less for radical innovation (Cooper, 2008, p. 223). Due to the linear course of this management model and the tendency of organizations to discard ideas and concepts with high uncertainty, radical ideas are over-proportionally likely to be rejected from this management model (Sethi & Iqbal, 2008, p. 127). Therefore, other management models have been established, e.g. *the probe and learn process* (Lynn et al., 1996), *the DIA-process* (Colarelli O’Connor & Ayers, 2005) and increasingly-discussed methods such as *the Lean Startup* (Ries,

2011) and *Design Thinking*[6] (Brown, 2008, 2009; Kelley, 2001). All of these emerging management models are iterative and agile, commonly used for radical innovation and by startups. Cooper (2008) reviews major misconceptions about the stage-gate process in practice, the most notable one being that it is perceived as linear, while the model is actually is of an iterative nature (Cooper, 2008, p. 216). Hatchuel, Le Masson and Weil (2001) indicate the importance of the existence of an innovation management model by stating that well-defined management models stimulate good input (Hatchuel et al., 2001, p. 11).

Regardless of which kind of innovation or management model an organization pursues, they all have one thing in common: each of these models has a front-end of innovation. This concept will be further elaborated in the next chapter.

Conclusion

- Innovation is defined as the implementation of new or improved products, services, or technologies, while invention is the discovery of something new that is not marketable or does not address a customer need.
- Innovation is seen as an important driver for competitive advantage and remains a top priority for the majority of companies.
- Different innovation typologies comprise product, process, marketing, organizational, business model innovation, and research projects.
- The notion of innovativeness classifies innovation activities along different dimensions such as fit and familiarity to distinguish incremental from radical activities.
- The stage-gate process is the main innovation management model applied in organizations and guides innovation from idea to launch through several stages.

[6] Design thinking is a mind-set finding innovation at the core between desirability, viability and feasibility, exploring ideas through a user-centric iterative process comprising six steps: understanding the challenge, observing the user, defining a point of view for the challenge, ideating, prototyping and testing (Brown, 2009).

2.3 Management of the Front-End of Innovation

This chapter elaborates on the definition of the front-end of innovation, as well as its various management models and phases.

2.3.1 Definition

The **front-end of innovation** is known as the first and a very important – if not the most important – phase of new product development (Khurana & Rosenthal, 1998; J. Kim & Wilemon, 2002a; Koen et al., 2001; Koen & Bertels, 2010; Murphy & Vinod, 1997; Reid & de Brentani, 2004; Reinertsen, 1999; Russell & Tippett, 2008; P. Smith & Reinertsen, 1991; Zhang & Doll, 2001).

It ranges from idea generation to concept development and finishes upon the start of development (SOD) (Murphy & Vinod, 1997, p. 5). For Koen et al. (2001), this phase encompasses everything that happens prior to the kick-off of the more systematic and strict development phase (Koen et al., 2001, p. 46), while Reid and de Bretani (2004) consider it as the time and effort spent before discussing the idea in a first official meeting (Reid & de Brentani, 2004, p. 170).

Kim and Wilemon (2002) explain the phase starting from the positive evaluation of an opportunity, which is subsequently further elaborated and evaluated once again. It ends after the organization's decision to allocate considerable budget for further development and market launch. "Thus we define the FFE as the period between when an opportunity is first considered and when an idea is judged ready for development" (J. Kim & Wilemon, 2002a, p. 269).

Smith and Reinertsen (1991) first coined the expression of the *fuzzy* front-end, emphasizing its unstructured character and proposing more attention to this phase for time-saving and cost reduction reasons (P. Smith & Reinertsen, 1991). They claim that the proper management of this phase leads to time reduction of up to 50% (P. Smith & Reinertsen, 1991, p. 2). This, in turn, leads to less cost being spent on resources, more sales due to enhanced sales life and a larger pricing premium in the beginning (P. Smith & Reinertsen, 1991, p. 4f). The fuzziness of the front-end of innovation is described through the increased risk, uncertainty as well as the unpredictability of customer requirements, technological feasibility and the competitive situation (P. Smith & Reinertsen, 1991; Zhang & Doll, 2001, p. 95).

The front-end of innovation[7] is also recognized under terms such as *pre-phase 0* (Khurana & Rosenthal, 1997, 1998), *pre-project activities* (Verganti, 1999), *pre-development-activities* (Cooper, 1988), *early stages of product development* (Nobelius & Trygg, 2002) or *early innovation phases* (Lichtenthaler & Savioz, 2004).

Since its first appearance, this phase underwent changes and further research, not only taking the *fuzziness* out of the name – thereby declaring it simply the front-end of innovation (FEI) – but also clarifying and

[7] In the following, the term front-end of innovation will be used.

defining steps that need to be taken to make it more manageable (Koen et al., 2001; Poskela & Martinsuo, 2009; Reinertsen, 1999).

The front-end of innovation is very distinct from the rest of the NPD. Zien and Buckler (1997) define *micro cultures*, meaning that the front-end of innovation has a different management culture than the development phase after SOD. These cultures stand opposed to each other due to the *un-business-like* and chaotic nature of the front-end of innovation (Zien & Buckler, 1997, p. 276). The un-business-like character can best be described by opposing FEI and the development phase. The nature of the FEI is unstructured, experimental and creative since one or several vague ideas have to be turned into a concept without being able to clarify the details of its shape, features or applied technologies. Thus, the main goal in the FEI is the minimization of risk and uncertainty and the more detailed description of preliminary ideas (Moenart et al., 1995, p. 249). In the development phase, detailed concepts are already prepared for testing and manufacturing with precise milestones and a systematic structure (Koen et al., 2002; Zien & Buckler, 1997). While the FEI produces ideas and turns them into early concepts that are modifiable, have a broad focus and can only be assessed qualitatively, concepts in the development phase after SOD are expected to produce a product, indicating greater concept maturity with a limited focus that is difficult to adjust. Besides, these concepts are assessed by accurate and pre-determined indicators and – unlike in the FEI – precise work packages have to be processed (J. Kim & Wilemon, 2002a, p. 270; J. Kim & Wilemon, 2002b, p. 270). Concepts in the development phase are elaborated by a team with a high allocation of budget and resources, significant commitment of the management and detrimental consequences if the project is stopped. On the other hand, concepts in the FEI are detailed by individual employees with little or no budget, and thus they can only do limited harm (J. Kim & Wilemon, 2002a, p. 270; Koen et al., 2002, p. 6; Zien & Buckler, 1997, p. 279). Furthermore, revenue estimations and potential launch dates are very unclear in the FEI, while they are increasingly specified when the concept becomes more mature in the development-phase after SOD. Table 4 summarizes the opposing characteristics of the front-end of innovation and the product development phase.

Characteristic	Front-end of innovation	Development-phase after SOD
Nature of work	Unstructured, chaotic, experimental, creative, non-schedulable,	Systematic, structured, disciplined, goal-oriented, urgency-driven
Type of activity	Risk and uncertainty minimization, optimization of idea and concept potential, concept specification	Detailing of concept, testing, preparation of manufacturing, focus on quantitative objectives and milestones
Maturity of concepts	Easily modifiable	Difficult to adjust
Type of information for evaluation	Qualitative, estimated	Quantitative, accurate, pre-determined
Expected outcome	Concept	Product
Focus	Broad and widespread	Limited and precise
Extent of formalization	Mainly kept down, open for ideas and irritations	Very formalized with precise work packages, no disturbances welcome
Staffing	Individual or few people	Designated team
Budget allocation	Low budget/variable funding, depending on scope of project	High budget
Commitment of upper management	Low	High
Consequences in case of abandonment	Limited	Significant
Revenue estimation	Vague	Specified, accuracy increases with approaching launch date
Launch date	Uncertain	Definite

Table 4: Cultural Differences between Front-End of Innovation and Development Phase after SOD

Notes:
Source: J. Kim & Wilemon, 2002a, p. 270; Koen et al., 2002, p. 6; Zien & Buckler, 1997, p. 279

The gradual progression of the level of uncertainty and lack of structure over the course of an innovation project is depicted in Figure 9, corresponding to the need for a more stringent management in the front-end of innovation (J. Kim & Wilemon, 2002a, p. 270).

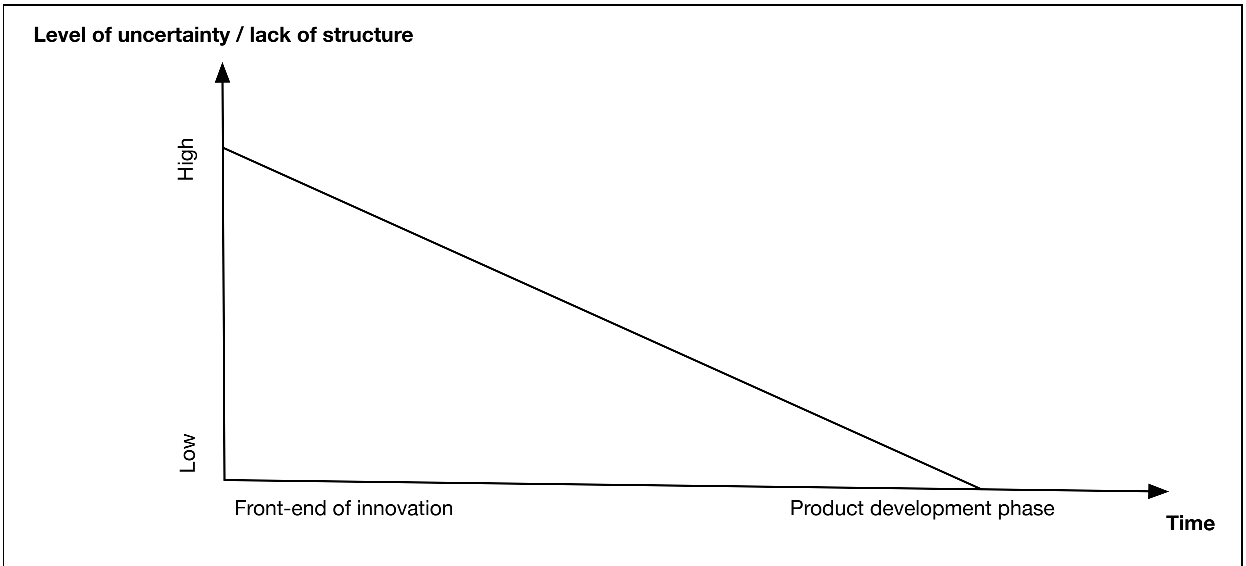


Figure 9: Development of Uncertainty over Time in Innovation Projects

Notes:
Source: J. Kim & Wilemon, 2002a, p. 270

2.3.2 Importance and Competitive Advantage

The front-end of innovation holds significant meaning for the whole NPD (Booz Allen & Hamilton, 1982; Jaruzelski et al., 2012; Markham, 2013; Reid & de Brentani, 2004), since activities in the front-end of innovation are linked to NPD success (Cooper & Kleinschmidt, 1987, p. 180; Dwyer & Mellor, 1991, p. 47; Moenart et al., 1995). The creation of value takes place in the front-end of innovation (Markham, 2013; Reid & de Brentani, 2004, p. 172) and for Reid and de Bretani (2004) the "root of success" for radical innovation lies in this phase (Reid & de Brentani, 2004, p. 170). Being able to manage the front-end of innovation can bring distinct competitive advantages to companies (J. Kim & Wilemon, 2002b, p. 27). The exertion of influence towards the product-to-be decreases along the course of the NPD process, meaning that within the front-end of innovation the leeway for change is highest and "benefits resulting from improvement in the front-end are likely to far exceed those that result from improvements aimed directly at the design engineering process" (Zhang & Doll, 2001, p. 95). Because the actual costs of mismanagement of this phase can only be seen at later stages, strong attention must be paid to the front-end of innovation (P. Smith & Reinertsen, 1991, p. 44) or as Zhang & Doll (2001) put it: "[m]ost projects do not fail at the end; they fail at the beginning" (Zhang & Doll, 2001, p. 95).

Having to manage various information from different sources (Zahay, Griffin, & Fredericks, 2004) and having to decide which ideas and concepts should be prioritized and how resources should be allocated makes the front-end of innovation a highly complex and challenging task for innovation managers (J. Kim & Wilemon, 2002b, p. 269). Therefore, researchers have developed different management models to handle this uncertain and chaotic phase. The following chapter examines different management models for the front-end of innovation.

2.3.3 Management Models

Management models for the front-end of innovation can be divided into three distinct types: linear, iterative and undirected (de Ven & Cheng, 1996, p. 594). Linear management models contain well-defined work packages that process linearly with precise evaluation gates (Cooper & Kleinschmidt, 2001), while iterative models advance cyclically (Koen et al., 2001) and undirected models act on the notion of individuals and the dispersion of ideas through intrapreneurs and networks (Reid & de Brentani, 2004). The most prominent models for structuring and managing the front-end of innovation will be introduced in the following.

2.3.3.1 Linear Management Models

Pre-Development Activities by Cooper (1988)

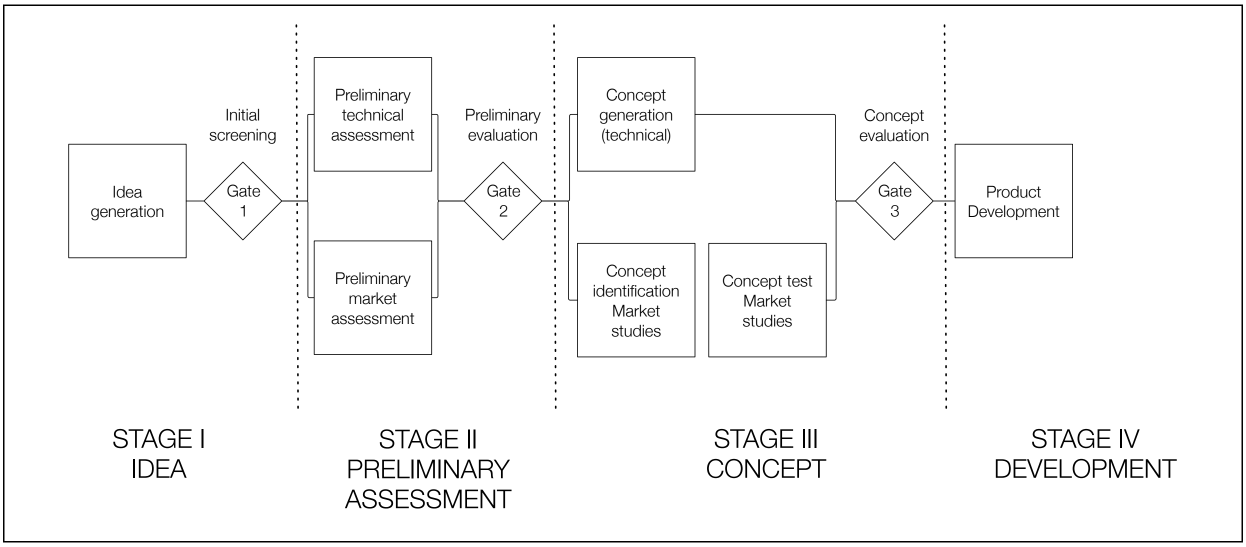


Figure 10: Pre-Development Activities by Cooper (1988)

Notes:
Source: Cooper, 1988, p. 234

Apart from the stage-gate model introduced in Chapter 2.2.5, Cooper assigned the first three stages to the front-end of innovation (Cooper, 1988) and termed them *pre-development activities* (see Figure 10 for process details). Deliverable of the pre-development activities is a concept that is decided upon, whether or not it enters the product development phase. The model comprises the stages of ideation, preliminary assessment, and concept (Cooper, 1988, p. 243).

The first stage comprises the generation of new ideas and their screening. Although the source of ideas can be various, using customers or sales people for direct product feedback is encouraged. Good ideas generated in this first phase need to be segregated from the bad ones by evaluating them on strategic fit, technical feasibility, or market size, which is part of the screening process. Thus, the most promising ideas gain a provisional go to engage in further work to demonstrate their potential (Cooper, 1988, p. 242).

The preliminary assessment incorporates dedicated budget spent on uncertainty reduction through information gathering regarding technical feasibility and market assessment. Surpassing this gate results in a significant increase of budget allocation (Cooper, 1988, p. 242).

The concept definition stage comprises the comprehensive formulation of the concept, enriching the raw idea with details. Specifically, the technical and design perspectives of the concept are required, showing the benefits in comparison to existing products. Before entering into the final go/no-go-decision, the concept is tested (Cooper, 1988, p. 244).

The stage-gate model possesses some major advantages, making it the most common model in practice. These benefits primarily comprise the clear path that each idea is following and the easy understanding of the overall process model. It is an effective and quick way to process ideas, and it balances out potential returns and risk. Due to the strict decision criteria and their linear progression, ideas with higher uncertainty or a low fit and familiarity might be disadvantaged, privileging incremental ideas. Thus, the model disregards the requirements of radical ideas, making it the main disadvantage of the stage-gate process (Bonner, Ruekert, & Walker, 2002, p. 240; Kock, Heising, & Gemünden, 2015, p. 544; Sethi & Iqbal, 2008, p. 127). In his latest paper, Cooper (2008) describes more iterative approaches incorporating his stage-gate logic, giving more awareness to ideas with a high degree of uncertainty (Cooper, 2008, p. 223). Furthermore, the management model omits the opportunity identification and alignment with corporate strategy, making it a model that cannot be described as holistic.

Linear model by Khurana and Rosenthal (1998)

The second prominent linear model of the front-end of innovation is described by Khurana and Rosenthal (1997, 1998). Derived from in-depth case studies, the front-end model contains three main phases: pre-phase zero, phase zero and phase one. Besides these phases, so-called foundation elements are required accompanying the whole NPD process and acting as a base for all activities. These foundation elements comprise a well-defined product strategy and a well-thought-out innovation roadmap. Furthermore, the organizational structure is described as a facilitator for new product development endeavors. This includes factors such as structural configurations, communication and role descriptions (Khurana & Rosenthal, 1997, p. 104).

The front-end phases contain the elaboration on the product concept and the definition of requirements such as market estimates, concept details, and project plans. The product concept covers an initial description of customer needs and benefits, market figures and forecasts, the competitive surrounding, and alignment with the product strategy. The goal of the front-end process is a product concept for the management that either allocates more resources or stops the project (Khurana & Rosenthal, 1997, p. 104).

Pre-phase zero is the discovery of a new business opportunity. If this opportunity is evaluated as worth exploring after an initial check, in *phase zero* a small team is put together to elaborate on the product concept. *Phase one* analyzes the feasibility of the product definition market- and technology-wise. After presenting the product definition, the business case and a decision are made, and the front-end of innovation ends (Khurana & Rosenthal, 1997, p. 104). Figure 11 shows the overview of the front-end process.

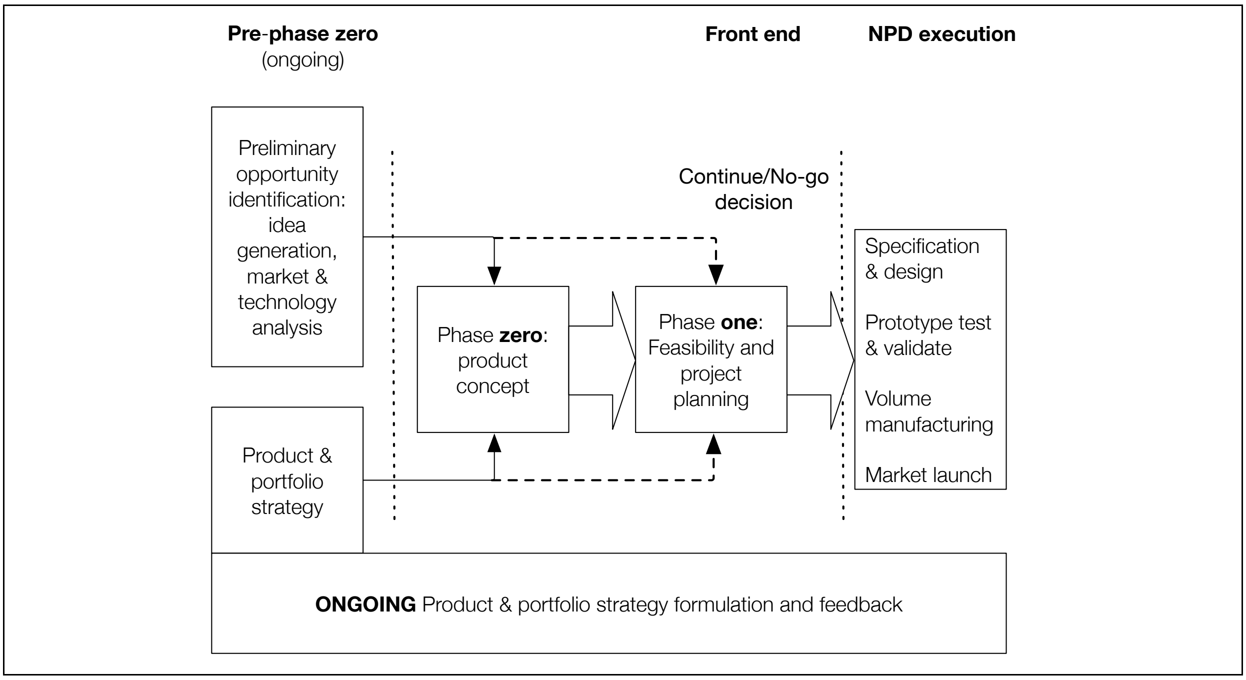


Figure 11: Management Model for Front-End of Innovation by Khurana and Rosenthal (1998)

Notes:
Source: Khurana & Rosenthal, 1998, p. 59

The distinguishing factor from Cooper's process is the emphasis that Khurana and Rosenthal (1997, 1998) place on the strategic phase of the front-end of innovation. This phase is described as a success factor for the whole NPD (Khurana & Rosenthal, 1997, p. 104). It comprises the definition and announcement of a strategic vision and a product strategy for the facilitation of go/no-go decisions. Furthermore, the strategic phase contains the portfolio management, which coordinates new concepts across the entire business to equalize risk, revenue potential, core and new business as well as timing, while matching the concepts with the overall strategy (Khurana & Rosenthal, 1997, p. 104). Thus, the strategic phase (1) holds importance throughout the whole NPD process and (2) is set prior to ideation. Thus, it is a prerequisite for all other phases in the front-end of innovation (Khurana & Rosenthal, 1997, p. 105).

In a second study, Khurana and Rosenthal (1998) emphasize a holistic view on the front-end of innovation, incorporating the business strategy as one of the main factors for success. In empirical studies, the alignment of new product concepts with the business strategy was named as the main success factor and challenge (Khurana & Rosenthal, 1998, p. 62f.). The research of Khurana and Rosenthal (1998) further indicates that the transfer of the strategy into guidelines for the front-end of innovation is a common problem requiring special attention (Khurana & Rosenthal, 1998, p. 65).

iNPD – integrated New Product Development by Cagan and Vogel (2002)

Cagan and Vogel (2002) introduced a new approach for the front-end of innovation, namely the iNPD (integrated new product development). They describe the iNPD as a mindset based on the aspects of (1) interdisciplinarity, (2) focus on the customer and (3) stressing the importance of qualitative research methods in the front-end of innovation and quantitative research methods in later stages (Cagan & Vogel, 2002, p. 108).

Besides setting up a team with diverse knowledge backgrounds, the process comprises four phases, omitting the strategic phase and starting with the identification of opportunities (Cagan & Vogel, 2002, p. 109). The four phases of the iNPD are:

1. Identifying opportunities
2. Understanding opportunities
3. Conceptualizing opportunities
4. Realizing opportunities

Cagan and Vogel (2002) describe the process as customer-centric and the underlying mechanism as *managing options* through a *sequence of funnels*. "[...] [O]pportunities are expanded through a gathering process and then filtered down to one or a few ideas based on the team's analysis and interpretation. These remaining ideas are then expanded again in more focused depth with one investigation [...] leading to the next area of focus" (Cagan & Vogel, 2002, p. 110).

As shown in Figure 12, within the first phase (1) of the process, opportunities are identified through the analysis of social, economic and technological factors that lead to product opportunity gaps (Cagan & Vogel, 2002, p. 107). The second phase (2) focuses on understanding the needs of the customer mainly through qualitative techniques and value of opportunity analysis[8], while the third phase (3) translates the most promising ideas into concepts. The fourth phase (4) transforms these concepts into early prototypes for proof of concept and overall feasibility (Cagan & Vogel, 2002, p. 113).

[8] Chart measuring value opportunities (attributes adding a benefit to the product), which can be split up into the categories of "emotion, aesthetics, identity, ergonomics, impact, core technology and quality" (Cagan & Vogel, 2002, p. 62).

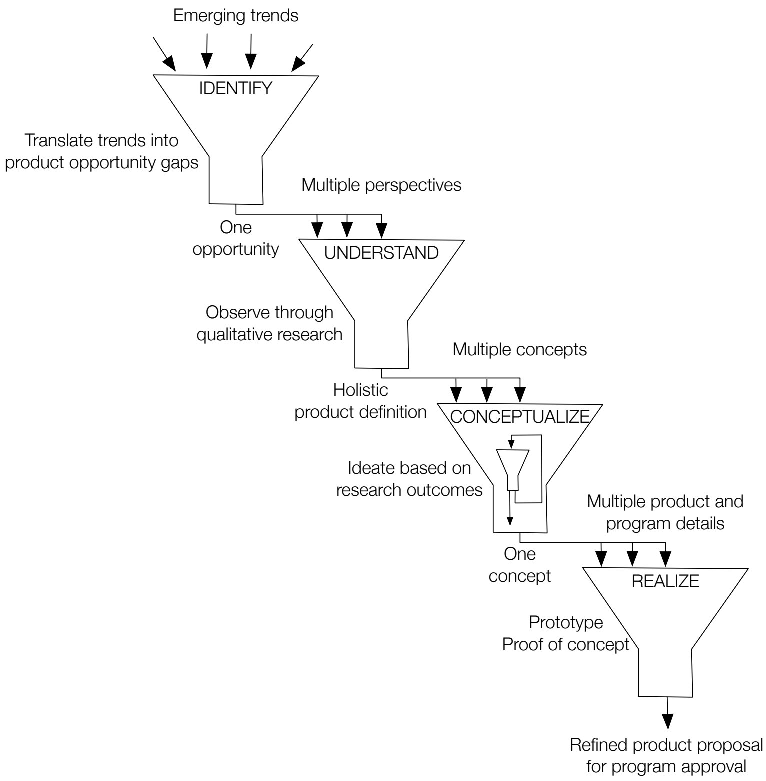


Figure 12: iNPD Management Model by Cagan and Vogel (2002)

Notes:
Source: Cagan & Vogel, 2002, p. 112

Applied properly, this way of structuring the front-end of innovation is said to "reduce downstream development problems in parts integration, manufacturing quality, and missed opportunities in the style and features of the product" (Cagan & Vogel, 2002, p. 109). Furthermore, through applying this process, the probability of SOD-approval increases through well-grounded and elaborated concepts (Cagan & Vogel, 2002, p. 136). iNPD is distinct from other FEI models through the strong customer research focus, which in turn requires more resources and time allocated to the front-end of innovation, which Cagan and Vogel (2002) deem as a success factor in the front-end of innovation. Through the weak link between strategy and opportunity identification, the process might lack sufficient alignment with the overall objectives of the company.

2.3.3.2 Iterative Management Models

New Concept Development Model (NCD) by Koen et al. (2001, 2002)

Koen et al. (2001) have developed an iterative management model called the *new concept development model*, comprising three main parts: (1) a process with five components, (2) an engine fueling the components and (3) external factors influencing the process components and the engine (Koen et al., 2001, p. 46). The following figure shows the model with its different process elements.

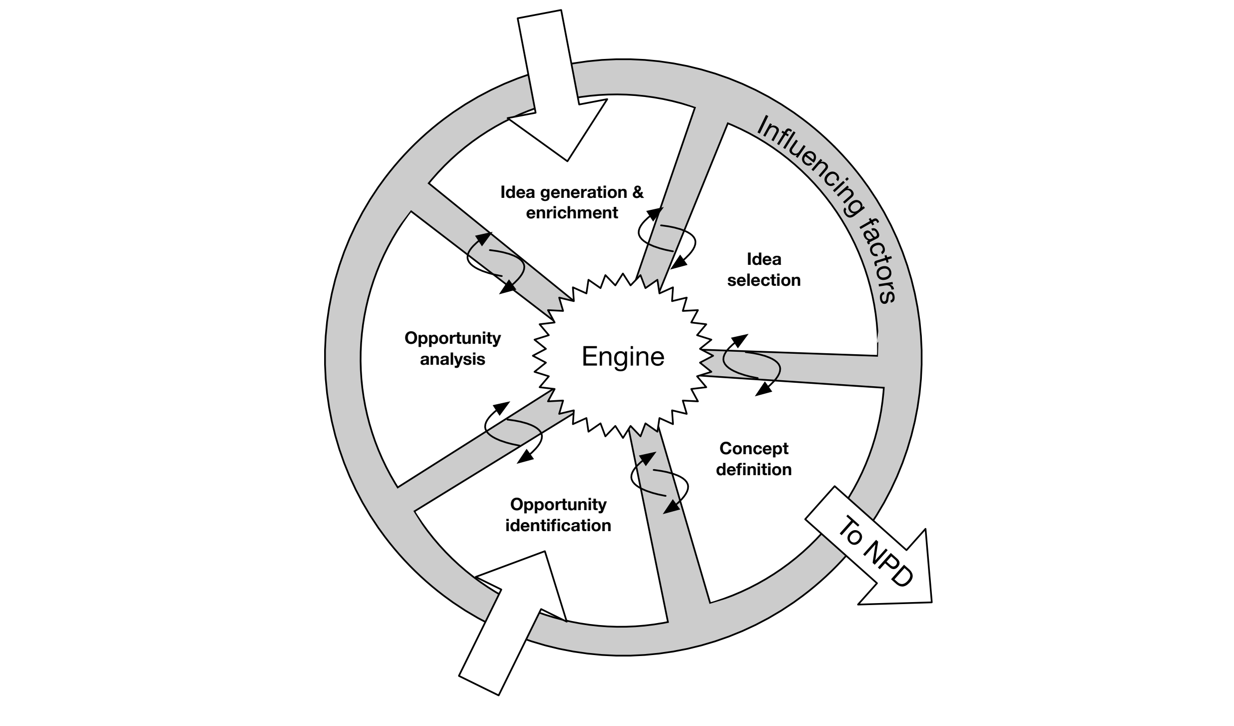


Figure 13: NCD Management Model by Koen et al. (2002)

Notes:
Source: Koen et al., 2002, p. 8

The process comprises five main phases: (1) opportunity identification, (2) opportunity analysis, (3) idea generation & enrichment, (4) idea selection and (5) concept definition.

The *opportunity identification* comprises the discovery of business or technology ideas. These ideas are vague, driven by the company's strategy and goals and can either be radically new market segments or minor technological advancements improving the efficiency of existing products. The way in which ideas are discovered can be either formal – taking external environment and trends into account and using creativity methods – or informal, driven by personal creativity sparks or input from the upper management (Koen et al., 2001, p. 50). During *opportunity analysis*, the identified ideas are assessed from a technological and business perspective (Koen et al., 2001, p. 50). *Idea generation and enrichment* is the phase that turns vague ideas into preliminary product concepts by enhancing and shaping them (Koen et al., 2001, p. 51). The detailed product concepts undergo a go/no-go decision during the *idea selection* phase. Since information is still incomplete and estimations are uncertain, the decisions regarding following up on certain ideas are described as *educated guesses*. Decisions are made by either individual selection of the upper management or an advanced portfolio approach and risk balancing (Koen et al., 2001, p. 51). The final step is the *concept definition* phase, during which the detailed business case and the project proposals for further elaboration in the development-phases are created. (Koen et al., 2001, p. 52).

The five above-described phases of the front-end of innovation are not to be understood as a linear approach, but rather a random order not following a specific structure, also indicated by the overlapping arrows (Koen et al., 2001, 2002, p. 8). The model is designed as a circle to show that ideas and opportunities inside can move around between all phases, implying that the phases can be used in any direction and certain phases can be repeated (Koen et al., 2002, p. 9).

All of the steps described above are driven and influenced by the *engine*, which contains the culture and the leadership of a company, as well as the vision and the strategy. The engine is the part that is controllable by the company (Koen et al., 2001, p. 49, 2002, p. 8). The *environment* influencing the engine and the process steps contain the organization's competency profile and identified technologies, as well as the external world, such as competition, legal regulations or sales channels (Koen et al., 2001, p. 49).

The NCD emphasizes a holistic view on the front-end of innovation, similar to Khurana and Rosenthal (1997, 1998), describing the alignment to the strategy as a critical success factor. To ensure innovation with added value to the company, the alignment of any activity in the NPD with the overall strategy has to be guaranteed (Koen et al., 2002, p. 12f.; Koen & Bertels, 2010, p. 236).

In distinction to the linear models, all process steps happen in random order and influence each other repeatedly, accounting for the increased *fuzziness* and uncertainty during the front-end of innovation. The unsystematic order of the phases seems more natural when considering that ideas are often created and developed through experimentation and recombination, and thus the order responds more to the needs of more uncertain or radical ideas and their requirement. The downside of this model is the missing precision regarding the exact steps to be followed to advance an idea.

Iterative Model by Smith and Reinertsen (1991)

Another iterative process model for the front-end of innovation is proposed by Smith & Reinertsen (1991). Although Smith and Reinertsen (1991) emphasize the importance of planning the project before SOD, they agree that it might delay the project and increase risks. Thus, they present a front-end management model that parallelizes certain product planning and design activities (P. Smith & Reinertsen, 1991, p. 53). In their so-called *truss model*, planning elements that are vital for the execution of the project are resolved very early, while design activities are brought forward, which usually happen later in the process. Figure 14 shows the outline of the model with its six planning and designing steps that can be synchronized.

The first element of planning has the goal of detailing the idea to develop a common understanding. The solution space is minimized, and a common vision of features is specified. The next step comprises the detailing of concrete features for hand-over to the second design stage, in which layout and design are determined. Since sales forecasting is the step with the greatest uncertainty, this step is placed last in the front-end of innovation (P. Smith & Reinertsen, 1991, p. 55f.). Besides the overlapping of usually dispersed activities, Smith and Reinertsen (1991) stress the constant stream of information between marketing and engineering and between the two activity flows, which draws activities closer together and strengthens the whole process (P. Smith & Reinertsen, 1991, p. 57;155). Synchronizing activities implies working on incomplete information, enforcing communication and quick feedback loops and iterations to reach the common goal of a new product (P. Smith & Reinertsen, 1991, p. 159).

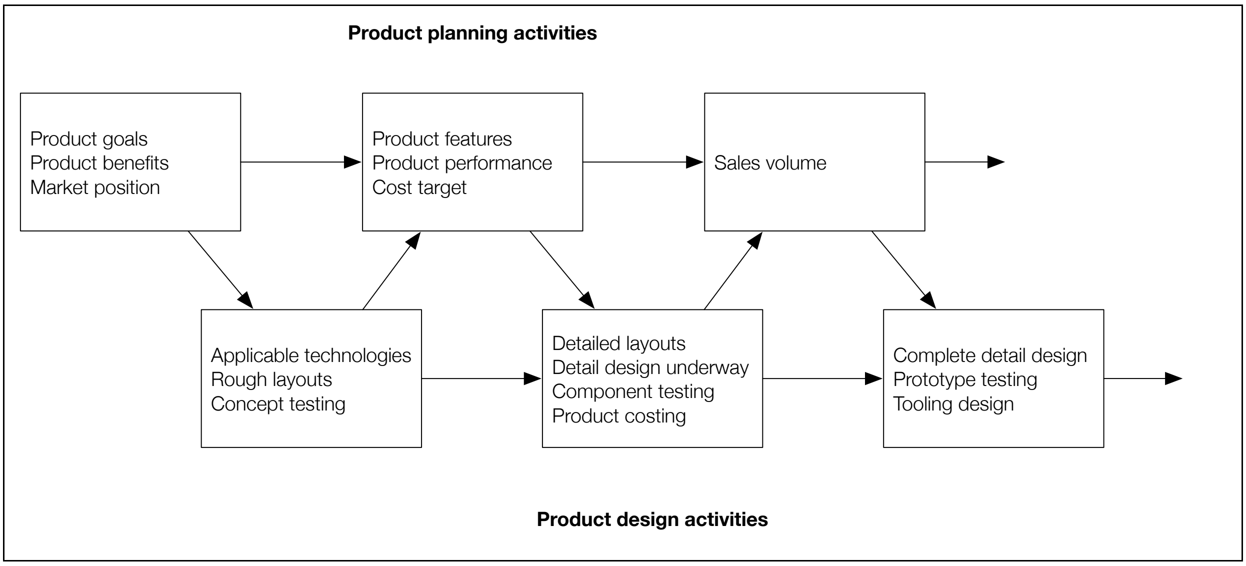


Figure 14: Iterative Management Model by Smith & Reinertsen (1991)

Notes:
Source: P. Smith & Reinertsen, 1991, p. 55

The depicted process of Smith and Reinertsen (1991) has the ability to speed up the front-end of innovation due to the stream of parallel activities. Additionally, this model responds to the current trend of iterative management models like design thinking and caters to the need for elaborating highly uncertain ideas. In comparison to Koen et al. (2002) and Khurana and Rosenthal (1998), this process model omits the strategic phase and opportunity identification and emphasizes the planning activities, while decision criteria are not further examined.

2.3.3.3 Undirected Management Models

Undirected management models are primarily driven by people and information flow, not focusing on process steps in a sequential or random order (Cheng & van de Ven, 1996, p. 601).

Front-End Model for Radical Innovation by Reid and de Bretani (2004)

Reid and de Bretani (2004) present their undirected model, which is especially suited for radical innovation. In their proposed model – shown in Figure 15 – ideas do not undergo a specific process, but rather they pass interfaces, defined as points of interaction and decision. First, the idea passes the *boundary* interface between the surroundings (primarily external, but they can be internal in large organizations) and an individual that is boundary-spanning[9]. During this phase, the boundary-spanner recognizes relevant information – usually comprising unspecific opportunities or needs – and channels it into the corporation (Reid & de Brentani, 2004, p. 179). Thereafter, information is transferred to a gatekeeper, which can be the same person as the boundary-spanner. In this phase, the information value is evaluated (concerning whether the idea is worth sharing) and the corresponding department or area with which to share it is identified, sometimes accompanied by first ideas or concepts (Reid & de Brentani, 2004, p. 180). Following the gatekeeper interface, more information regarding the idea is gathered to evaluate it profoundly and formally. The *project* interface then decides whether or not to allocate resources and budget for a project, usually done by the upper management (Reid & de Brentani, 2004, p. 181).

Reid and de Bretani (2004) emphasize the particular needs of radical ideas with their front-end model. This notion complies with current research on how to manage radical innovation (Colarelli O'Connor & Ayers, 2005; Colarelli O'Connor et al., 2008; Leifer et al., 2000) and the awareness that incremental innovation has to be managed differently than radical innovation to become successful.

Reid and de Bretani (2004) also emphasize the importance of a strategy for radical innovation. They suggest that competitive advantage relies on the right idea selection technique, which is influenced by the quality and deployment of the *strategic web*. For Reid and de Bretani (2004), the strategic web contains the identified strategic directions of a company but is permeable, whereby new ideas and concepts can be woven into the web (Reid & de Brentani, 2004, p. 181).

[9] Boundary spanners are individuals who link the company to the external environment. They serve as an important information bridge between their area of expertise and the outside world (Tushman, 1977, p. 598). They usually have strong connections inside and outside the organization, are communicative, versatile and technically savvy (Tushman & Scanlan, 1981, p. 302).

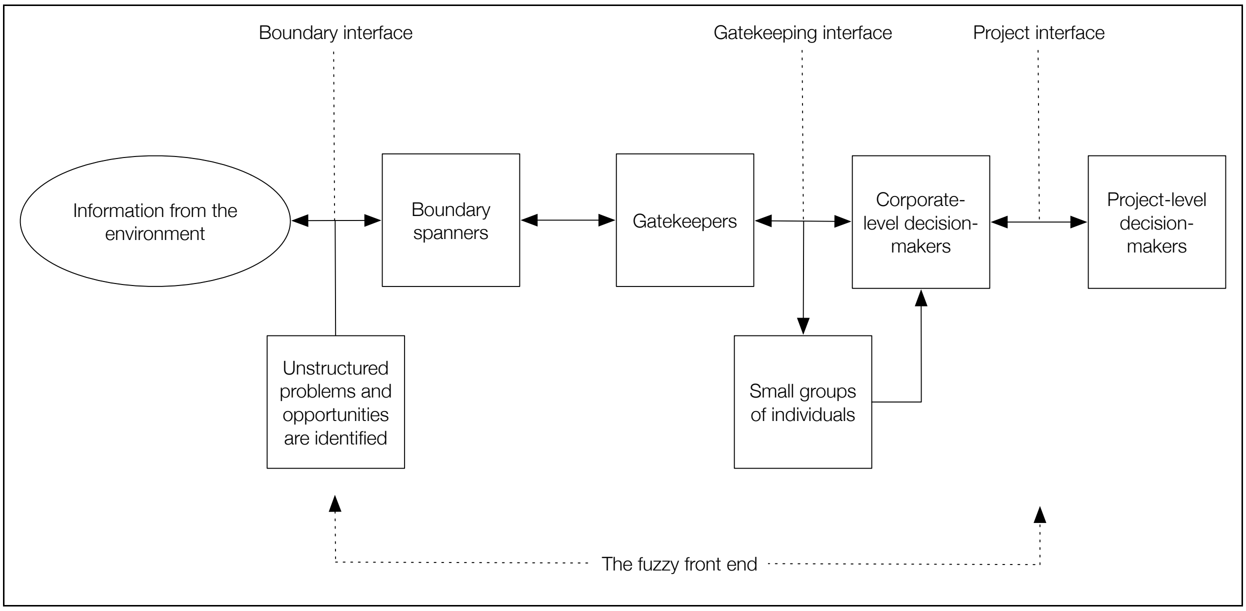


Figure 15: Undirected Management Model by Reid and de Bretani (2004)

Notes:
Source: Reid & de Brentani, 2004, p. 178

Similarly, Nobelius and Trygg (2002) discovered through their explorative case-studies that the front-end process steps differ depending on the project scope (incremental, platform, research). They call for more flexibility in the front-end of innovation, rejecting pre-planned universal phases. Following their results, they suggest adapting the model according to the project and choosing the order and type of phases within the innovation team (Nobelius & Trygg, 2002, p. 339).

Reid and de Bretani (2004) account for the notion that innovation is based on networks and people, thus turning the management of innovation in the front-end to a more human-centered and network approach based on information flow. Especially for radical innovation, this model overcomes process hurdles regarding very early idea evaluation, trusting the instincts of the boundary spanners. On the other hand, this approach does not take existing road-maps, strategy or company vision into account, risking the alignment of ideas and the objectives of the company. The approach assumes that the boundary spanners and gatekeepers possess the strategic knowledge, applying it to every type of information that they gather and distribute, thereby functioning as strategic filters themselves.

The next chapter compares the stages in the front-end of innovation from different management models and outlined their similarities and differences.

2.3.3.4 Comparison of Management Models

Reflecting on the above-described management models for the front-end of innovation, it can be said that all of them have a specific objective: they facilitate the development of ideas into concepts, reduce uncertainties and risk and prepare concepts for SOD. Furthermore, all of these models serve the purpose of reducing the number of concepts by making them comparable and assessing their value for the organization. Where they differ is the degree of formalization in transforming ideas into concepts. Especially the iterative and undirected management models propose less rigorous approaches in terms of pre-determined stages and criteria and the order in which they are taken. Furthermore, not all the models start and end with the same stage or use the same approach to manage innovation activities prior to SOD.

While Cooper (1988) divides the front-end of innovation into the phases *idea generation*, *preliminary assessment*, *concept generation* and *evaluation* (Cooper, 1988; Murphy & Vinod, 1997), other models omit ideation (Montoya-Weiss & O'Driscoll, 2000, p. 146; P. Smith & Reinertsen, 1991) or evaluation (Russell & Tippett, 2008, p. 38), add a strategic phase preceding idea generation (Reid & de Brentani, 2004, p. 171), focus on the environmental and corporate influencing factors (Koen et al., 2001, p. 48; Koen & Bertels, 2010, p. 234) or describe a flexible and undirected approach with no pre-defined order of phases (Nobelius & Trygg, 2002). Table 5 shows a comprehensive overview of the phases of the front-end of innovation, emphasizing parallels and dissimilarities between the models.

The **strategic phase** – also called opportunity identification – comprises "understanding the link between business strategy and NPD, simultaneously considering the portfolio of product development efforts and objective assessment of the particular NPD opportunities" (Khurana & Rosenthal, 1998, p. 59). For Koen (2001), it is the explicit identification of opportunity areas for growth or efficiency, such as "a breakthrough possibility for capturing competitive advantage", while Boeddrich (2004) calls them "strategic guidelines for innovation" (Boeddrich, 2004, p. 276; Koen et al., 2001, p. 50). The strategic phase precedes idea generation. Its tasks are (1) the alignment of corporate goals with those of innovation by defining an innovation strategy that determines the search boundaries, scope and locus for innovation search while simultaneously (2) aligning and guiding the portfolio of ongoing innovation activities by allocating resources (Khurana & Rosenthal, 1998, p. 59; Oliveira & Rozenfeld, 2010, p. 1340). The strategic phase helps to foster focus and alignment in the front-end of innovation and the distribution of resources according to the corporate objectives. Notably, about half of the front-end models do not address the strategic phase of the front-end of innovation. Only recently, increased emphasis has been placed on the strategic phase of the front-end of innovation (Boeddrich, 2004; Khurana & Rosenthal, 1998; Koen et al., 2001; Nobelius & Trygg, 2002; Trott, 2008).

Within the **ideation phase**, ideas are generated or collected from various sources, and they are often further detailed (J. Kim & Wilemon, 2002a, p. 30; Russell & Tippett, 2008, p. 38). This phase is often directly linked with the **initial screening**, evaluating the idea from different perspectives such as risk, market and technology attractiveness, and strategic fit (Herstatt & Verworn, 2004, p. 4; Khurana & Rosenthal, 1998; Russell & Tippett, 2008, p. 38).

After the most promising ideas are selected, in the **concept development phase** a refined concept is developed, "defining the product, its positioning, benefits and design" (Murphy & Vinod, 1997, p. 5). This indicates the detailed elaboration of the competitive environment, the evaluation of market and technological feasibility and testing of the initial concept (Khurana & Rosenthal, 1998, p. 60). Depending on the management model, either the front-end of innovation ends with the **concept evaluation phase**, deciding on the pursuit or termination of the innovation activity or the **project planning phase**. This phase encompasses the manifestation of internal capabilities and capacities as well as the alignment with other innovation projects and the composition of the project team, if not determined earlier in the process (Khurana & Rosenthal, 1997, p. 106). In this case, the **SOD** marks the end of the front-end of innovation.

Author	Strategy	Ideation	Initial screening	Concept development	Concept evaluation	Project planning
Description	*Alignment of corporate goals with innovation through innovation strategy, portfolio management*	*Generation of ideas*	*Evaluation of ideas and decision over continuation*	*Elaboration of ideas into product concepts*	*Detailed evaluation of concepts with market criteria, risk assessment, and technical feasibility*	*Planning of SOD, detailing of activities, milestones, and budget*
Cooper, 1988; Murphy & Vinod, 1997		Idea generation	Preliminary assessment	Concept generation	Evaluation	
P. Smith & Reinertsen, 1991				Project proposal	Business plan	Detailed project plan and product specifications
Khurana & Rosenthal, 1997, 1998	Pre-phase zero: product & portfolio strategy / opportunity identification	Pre-phase zero: idea generation	Pre-phase zero: market and technology analysis	Phase zero: product concept	Phase one: feasibility	Phase one: project planning
Montoya-Weiss & O'Driscoll, 2000			Idea qualification	Concept development	Evaluation	
Herstatt & Verworn, 2004		Phase 1: idea generation	Phase 1: assessment	Phase 2: concept development		Phase 2: project planning
Koen et al., 2001; Koen & Bertels, 2010	Opportunity identification & analysis	Idea generation and enrichment	Idea selection	Concept definition		
Cagan & Vogel, 2002		Identifying opportunities	Understanding opportunities	Conceptualizing opportunities		Realizing opportunities
Nobelius & Trygg, 2002	Opportunity identification / Mission statement	Concept generation	Concept screening	Concept definition	Business analysis	Project planning
Boeddrich, 2004	Strategic guidelines for innovation	Idea generation and adoption	Idea screening	Conceptual development		Preliminary projects
Lichtenthaler & Savioz, 2004	Determination of innovation need	Idea generation and collection	Idea evaluation and selection			Project formulation
Reid & de Brentani, 2004		Boundary interface		Gatekeeper interface		Project interface
Russell & Tippett, 2008		Idea collection	Idea screening		Project selection	
Trotter, 2011	Vision, strategy, and opportunity identification	Customer need and idea generation		Concept generation		Business case including value propositions
Frishammar, Lichtenthaler, & Kurkkio, 2012		Informal start-up: idea generation and refinement		Formal idea-study: preliminary product concept		Formal pre-study: project planning

Table 5: Comparison of Stages in the Front-End of Innovation

Notes:
Source: own representation
Sorted chronologically
Process steps taken from the different management models and activity description of the authors mentioned in the table

Two interesting aspects of the management of the front-end of innovation can be noted. First, only half of the presented management models emphasize strategic alignment in the front-end of innovation by outlining a **strategic phase**. However, since the strategic phase is described as a success factor for the front-end of innovation and the NPD (Khurana & Rosenthal, 1997, p. 104), this phase should be further elaborated. Second, there is a disagreement regarding the degree of **formalization** within the front-end of innovation (Nobelius & Trygg, 2002; Reid & de Brentani, 2004), which should also be further discussed. Both topics will be detailed in the following two chapters.

2.3.3.5 Formalization in the Front-End of Innovation

In order to effectively manage the front-end of innovation – which is also described as the weakest link of the process chain (Koen et al., 2001, p. 53) – and secure the orientation of innovation activities towards corporate goals, a formalization of the front-end phases is proposed, but discussed controversially (Khurana & Rosenthal, 1998; J. Kim & Wilemon, 2002b, p. 274; Markham, 2013; Nobelius & Trygg, 2002).

Definition

Formalization indicates the number of documented rules, procedures, responsibility protocols and workflows (Adler & Borys, 1996, p. 61; Deshpande & Zaltman, 1982, p. 15). It does not refer to management control systems, which comprise the capturing of financial and non-financial data to support managerial decision-making (Chenhall, 2003, p. 129). Formalization in the context of innovation management refers to the degree of structure and number of procedures to transform an idea into a concept and turn it into a project. It describes the steps and studies that must be taken to turn an idea into a concept and which criteria should be used to evaluate ideas and concepts, thus aligning the procedure for the whole organization (Kock et al., 2015, p. 542)

Formalization in Front-End of Innovation Literature

In a comparison of different front-end management models, Nobelius and Trygg (2002) argue against hieratic front-end models and for the need for greater flexibility in the front-end of innovation (Nobelius & Trygg, 2002, p. 338). Verworn and Herstatt (2001) reach a similar conclusion for non-incremental projects, asking for “flexible, learning-bases approach[es]” (Herstatt & Verworn, 2004, p. 9). Poskela and Martinsuo (2009) provide empirical evidence of a negative effect of front-end process formalization on strategic renewal under high technological uncertainty (Poskela & Martinsuo, 2009, p. 679). Strategic renewal describes a company’s competency to find new ideas and adapt to change (Poskela & Martinsuo, 2009, p. 673). The authors explain this result through the need for more flexibility and experimentation under uncertain conditions, which contradict the compliance with formal processes (Poskela & Martinsuo, 2009, p. 681). Another study by Abernethy and Brownell derives a similar conclusion, reporting that formalization leads to unfavorable results, especially with projects that show a high degree of uncertainty (Abernethy & Brownell, 1997, p. 244). All of these aforementioned studies have in common that formalization seems to be unfavorable when uncertainty is high. Buggie (2002) calls for a different approach in the front-end of innovation by giving clear indications for what is sought after (success criteria and search boundaries) and thereby giving more process autonomy by letting employees cater to these criteria and boundaries (Buggie, 2002, p. 11). Additionally, in various studies, it is reported that formalization reduces flexibility, increases bureaucracy and the time not spent on actual project work as well as reduced innovativeness and willingness to invest in innovation topics (Adler & Borys, 1996, p. 63; Amabile, 1998, p. 86; Tatikonda & Rosenthal, 2000, p. 405). Amabile (1998) could show in various examinations that giving freedom over how work is done supports creativity: “autonomy around process fosters creativity because giving people freedom in how they approach their work heightens their intrinsic motivation and sense of ownership” (Amabile, 1998, p. 82).

However, formalization is not only discussed negatively, as Zollo and Winter (2002) state: “[f]or a long time, the skeptics seemed to have the upper hand. More recently, there seems to be increasing willingness to see the formalization of operating routines in a positive light; e.g., as sometimes capable of producing an ’enabling’ rather than a ’coercive’ bureaucracy […]” (Zollo & Winter, 2002, p. 343).

Several authors agree that the formalization of the front-end of innovation has advantages, such as better overall performance and time-cutting (e.g., Ettlie & Elsenbach, 2007; Hüsig, Kohn, & Poskela, 2005; Hüsig & Kohn, 2003; Khurana & Rosenthal, 1998; Markham, 2013). In an extensive literature review, Hüsig and Kohn (2003) find evidence that formalization in the front-end of innovation is favorable for the project success (Hüsig & Kohn, 2003). Empirical studies show that an explicit structure and a formalized process create better front-end results (Ettlie & Elsenbach, 2007, p. 31; Hüsig et al., 2005, p. 864; Khurana & Rosenthal, 1998, p. 69; Markham, 2013, p. 9). Montoya-Weiss and O’Driscoll (2000) show that a formalized tool for idea management helps to structure the front-end without compromising creativity and innovation (Montoya-Weiss & O’Driscoll, 2000, p. 159). Kim and Wilemon (2002) perceive formalization as a cornerstone of effective front-end management (J. Kim & Wilemon, 2002a, p. 274), while Kleinschmidt, de Bretani and Salomo (2007) also show evidence that formalization of the NPD has a positive impact on the outcome, claiming that formalization allows coping with rising complexity (Kleinschmidt, De Brentani, & Salomo, 2007, p. 431). Interestingly, besides Kleinschmidt, de Brentani and Salomo (2007), the aforementioned studies do not discuss the degree of formalization that is needed for front-end success. Moenart (1995) presents a curvilinear relationship between formalization of R&D projects and front-end success, with medium formalization being the least favorable setting (Moenart et al., 1995, p. 251). By comparing one successful and one failed project, the researchers gain more insights into antecedents of the project planning process and information transfer between marketing and engineering in dependence on the success (Moenart et al., 1995, p. 247). For the authors, the explanation for the curvilinear relationship lies in the nature of the projects: long-term projects might need to be planned with less formalization, ensuring leeway for pivoting the project in the right direction. On the other hand, more formalized projects might be those of incremental or short-term nature (Moenart et al., 1995, p. 251).

Formalization and Ambidexterity

Regarding search strategies and the ambidexterity paradigm, Jansen et al. (2006) expose that there is no negative effect between exploration and formalization. They argue that formalization – if well-designed – can facilitate the reproduction and dissemination of explorative innovation in the organization (Adler & Borys, 1996, p. 70f.; Jansen et al., 2006, p. 1670). On the other hand, a study by Benner and Tushman (2002) discovers that process management activities emphasize exploitative undertakings over explorative innovation, indicating that established processes and routine increase exploitation and local search (Benner & Tushman, 2002, p. 699). In a study about the effect of bottom-up learning[10] on exploitation and exploration, Wei (2011) uncovers that formalization has a positive effect on exploration by reducing complexity, but only if bottom-up-leaning is perceived at a medium level. In her study, formalization also has a positive impact on exploitative innovation enhancing focus (Z. Wei, Yi, & Yuan, 2011, p. 326).

Thus, it can be concluded that a careful balance of formalization needs to be obtained in the front-end of innovation.

2.3.3.6 The Strategic Phase of the Front-End of Innovation

Definition

As outlined in the previous chapter, the strategic phase of the front-end of innovation aligns corporate goals with those of innovation by defining an innovation strategy. This innovation strategy determines the search boundaries, scope, and locus of innovation search. Furthermore, the strategic phase aligns and guides the portfolio of ongoing innovation activities by allocating resources (Khurana & Rosenthal, 1998, p. 59; Oliveira & Rozenfeld, 2010, p. 1340). This implies the coordination of new concepts across the entire organization to equalize risk, revenue potential, fit and familiarity as well as timing while matching the concepts with the overall search boundaries (Khurana & Rosenthal, 1997, p. 104). The strategic phase helps to foster focus and alignment in the front-end of innovation and thereby facilitates decisions concerning what concepts to follow or what innovation to seek. Thus, the strategic phase (1) holds importance throughout the whole NPD and (2) is a prerequisite for all other activities in the front-end of innovation (Khurana & Rosenthal, 1997, p. 105).

Importance and Implementation

Aligning and emphasizing strategy is seen as an important factor within the front-end of innovation by numerous authors (Booz Allen & Hamilton, 1982; Khurana & Rosenthal, 1997, p. 104, 1998, p. 59; J. Kim & Wilemon, 2002b; Mootee, 2011; Oliveira & Rozenfeld, 2010; Russell & Tippett, 2008, p. 38; Zhang & Doll, 2001, p. 120). Studies reveal that corporations that link corporate strategy and innovation activities

---

[10] Bottom-up learning is defined as the collection and usage of data from lower-level employees for innovation activities (Z. Wei et al., 2011, p. 314)

are more successful (Booz Allen & Hamilton, 1982, p. 6; Khurana & Rosenthal, 1998, p. 63) and possess ideas that deliver more sustainable value for the corporation (Koen et al., 2001, p. 49). Ideas can be prioritized more easily if the R&D-portfolio is aligned with the corporate strategy and resources can be balanced according to the strategy (Khurana & Rosenthal, 1998, p. 59). In a longitudinal study from Koen et al. (2014), strategy is shown to have a major impact on front-end performance and front-end efficiency (Koen, Bertels, & Kleinschmidt, 2014, p. 40). This shows that strategy is an important success factor for the front-end of innovation.

Several authors highlight the lack of existence of a documented innovation strategy or its communication (Booz Allen & Hamilton, 1982, p. 5; Dwyer & Mellor, 1991, p. 43; Hertenstein & Platt, 2000, p. 314; Koen & Bertels, 2010, p. 236; P. Smith & Reinertsen, 1991, p. 59). In their study, Khurana and Rosenthal (1998) specifically highlight that companies neglect the transfer of corporate objectives into an innovation strategy that guides innovation activities in the front-end of innovation (Khurana & Rosenthal, 1998, p. 65). Furthermore, they emphasize the difficulty in balancing the explicitness of such an innovation strategy to remain responsive to changes in the environment (Khurana & Rosenthal, 1998, p. 65). Thus, they propose to either incorporate innovation strategy as a cultural-driven approach with reliance on a cross-functional communication or through a formalized front-end of innovation that integrates the deduction of an innovation strategy as a permanent phase (Khurana & Rosenthal, 1998, p. 69). Both Martinsuo and Poskela (2011) and Oliveira and Rozenfeld (2010) highlight the use of criteria to judge the strategic alignment in the front-end of innovation (Martinsuo & Poskela, 2011, p. 908; Oliveira & Rozenfeld, 2010, p. 1346). In a study with Finnish companies, Martinsuo and Poskela (2011) could even show a relationship between the appliance of strategic criteria for innovation activity selection and the business potential at the project level. However, they highlight that these criteria might hold even more relevance at the business level rather than the project level. This implicates that successful corporations have understood the need to link corporate strategy to product strategies and product specific decisions while viewing the front-end of innovation from a holistic perspective, which is displayable through formal processes, strategic selection criteria or a cultural-driven approach (Khurana & Rosenthal, 1998, p. 65). Regardless of the approach, structuring the front-end of innovation needs to be effective and supportive, while neither increasing complexity nor perceiving it as an inhibitor:

> “Effective product strategy implementation is more than a periodic input to the front end to help judge a new product concept. There is an ongoing need for two-way interface between strategy and product innovation on issues of technology, markets and competition, competencies, resources and priorities.” (Khurana & Rosenthal, 1998, p. 72)

Thus, although applying an innovation strategy at the organization is seen as a success factor, the balance between the alignment and overly-rigid formalization of the process needs to be taken into account as an influencing factor (Ende, 2015, p. 482). This raises the question of what exactly strategic alignment and portfolio management have to look like in order to offer guidelines in the front-end of innovation for the organization to follow.

Strategy and Ambidexterity

"The most effective organizations have a front-end strategy for both new markets and disruptive businesses. In highly innovative companies, there is a distinct strategy for incremental and radical projects, both mediated by the portfolio" (Koen et al., 2014, p. 42). Besides the careful balance of formalization in the front-end of innovation, an effective innovation strategy needs to cater to both explorative and exploitative innovation. Thus, in terms of achieving contextual ambidexterity, organizations need a clear innovation strategy that determines the balance between exploration and exploitation. In case of reduced firm performance or changed external factors, the innovation strategy needs to be sufficiently flexible for organizations to re-align their innovation strategy and redefine the search boundaries and search strategies (focusing on either exploration or exploitation) (Greve, 2007, p. 950; Levinthal & March, 1981, p. 308). In a study with high technology companies, Cantarello et al. (2012) propose a multi-level approach to reaching ambidexterity, intertwining the operational and strategic level by offering deliberate tension in the search for innovation, which is checked and regularly dissolved by the top management. The authors also highlight the scarce research on how exactly ambidexterity during the search for innovation can be obtained (Cantarello et al., 2012, p. 45)

Two interesting notions can be derived from this: first, in order for organizations to build ambidexterity, the innovation strategy needs to exhibit a certain degree of flexibility and adaptability. Second, there is scarce research on the operationalization of such an innovation strategy that fosters ambidexterity.

Summing up, the strategic phase of the front-end of innovation holds strong importance but is often neglected in the preceding management models. Aligning strategic goals with innovation activities and converting these objectives into search boundaries and guidelines to follow, is a factor for sustainable success. Furthermore, formalization in the front-end of innovation remains a controversially discussed topic. Zien and Buckler (1997) state that the front-end of innovation has different management needs than the remaining NPD process (Zien & Buckler, 1997, p. 276), while the formalization opponents call for more flexible approaches in the front-end, especially for more radical ideas.

An instrument to balance formalization, set search boundaries, scope, and direction for innovation search, are so-called *innovation fields*, a practical phenomenon that has recently emerged, providing guidance and structure in the strategic phase of the front-end of innovation while applying a flexible degree of formalization. Innovation fields might be a means to turn search strategies into guidelines that define search boundaries and direction.

Conclusion

- The front-end of innovation – the first phase in the NPD – ranges from idea generation to the start of development and is distinct from the rest of NPD due to its unstructured and experimental nature.
- The goal of the front-end of innovation is the reduction of uncertainty and the development of concepts that are either terminated or followed up in NPD-projects.
- Since the main value creation takes place in the front-end of innovation and the degree of influence is highest, it is described as the most important phase of the NPD.
- Literature distinguishes linear, iterative, and undirected management models for the front-end of innovation.
- Despite their similarities, the management models for the front-end of innovation differ in the degree of applied formalization and sequence of stages, such as the omission or existence of a strategic phase in the front-end of innovation.
- There are mixed results for the degree of formalization in the front-end of innovation, and a careful balance is proposed.

2.4 Innovation Fields

This chapter provides the definition of innovation fields as a structuring element in the front-end of innovation, fostering ambidexterity. Types of applications for innovation fields are outlined, and the research question is derived.

2.4.1 Definition

"Innovation without purpose can result in innovation induced myopia" (Calantone et al., 2006, p. 419). A phenomenon to structure the strategic phase in the front-end of innovation that has been reported and described by practitioners[11] and academics are **innovation fields** (IF) (Cooper et al., 2004; Crawford, 1980; Gillier et al., 2010; Herstatt, 2002; Herstatt, Lüthje, & Lettl, 2001; Kleinschmidt et al., 2007; Mootee, 2011; Salomo et al., 2008; Talke et al., 2010). They were first described by Crawford (1980) as *target business arenas* that limit or guide product innovation activity within a determined search scope. Further research on this topic followed almost twenty years later[12] (Cooper, 2005; Gillier et al., 2010; Salomo et al., 2008; Talke et al., 2010). Since innovation fields are known under different synonyms (Salomo et al., 2008), Table 6 lists the main names and definitions.

[11] The following companies have been reported using innovation fields: 3M, Procter & Gamble, Medtronic, Degussa, Valeo (Salomo et al., 2008), UPS (Laurie et al., 2006), Nortel Networks (Leifer et al., 2000), Tefal (Hatchuel et al., 2001) and Wella (Clausen et al., 2012).

[12] There has been a second research strand around innovation fields in Germany in the 1980s, primarily coneptualizing this notion and elaborating on systematic deduction of innovation fields in organizations (Appelt, 1981; Kramer, 1977; Müller-Stewens, 1986; Pfeiffer, 1992; VDI, 1980).

Author(s)	Definition
Crawford, 1980, p. 4	"The **target business arenas** [are fields] that product innovation is to take the firm into or keep it in. These arenas are defined in four ways: By product type […], by end-user activity of function […], by technology […], by intermediate or end-user customer group […]."
R. Jonash & Sommerlatte, 1999, p. 3	"The next-generation model requires the construction of what we call **technology and competency platforms**, made up of a powerful blend of human skills, competencies, and state-of-the-art technologies, which can be tapped to generate improvements in growth and performance" […] a technology and competency platform is designed specifically to support and drive the growth of a given portfolio of innovations."
Hatchuel et al., 2001, p. 11	"The target of an innovation process is not a well-specified goal but what we suggest to call a '**field of innovation**' (IF): that is an area for innovative design."
Buggie, 2002, p. 11	"The very first thing to do is to step back a pace and establish a set of specific success criteria [for a **strategic innovation program**] which define, in advance, all of the essential attributes and desired characteristics of the ideal, next-generation new product line."
Cooper et al., 2004, p. 50	"A product innovation and technology strategy for the business should include, among other things, clearly defined NPD goals, **strategic arenas** or areas of focus, a product or technology roadmap (which maps the major initiatives over the next 5-10 years) and so on."
Colarelli O'Connor & Ayers, 2005, p. 29	"This company has taken the approach of identifying **growth platforms** based on independent initiatives already underway throughout the company, combining those that make sense, and devoting money and senior management attention to ramping those up to be very large businesses that will ultimately impact a number of the current business units. In other words, these are not white space opportunities, but rather gray space, or multi-aligned opportunities." "The CEO and CTO of this firm have defined five or six **technology-market domains** that are emerging as new business arenas, where there are currently few competitors, lots of advanced technology development activity, and a promising future market. The leadership of the company has a stated intention to dominate those spaces, and resources are dedicated to those programs from start to finish."
Laurie et al., 2006, p. 82	"All the companies grew by creating what we call **new growth platforms (NPGs)** on which they could build families of products, services and businesses and extend their capabilities into multiple new domains. The platforms provided a framework in which acquisitions served less as a direct driver of growth and more as a way of acquiring specific capabilities, assets and market knowledge. […] The scale of the platforms is strategic and material to corporation."
Salomo et al., 2008, p. 561	"**Innovation fields** consist of multiple innovation projects, which are typically related by one common theme, which can be a customer need, a core competence, a technology platform, or any combination of these"
Schuh, Orilski, & Wellensiek, 2009, p. 2	"In literature and praxis, the definition of concrete **search fields** is established to describe the technological information demand. Search fields define the dimensions of the required innovation with regard to content. Thereby, they limit the relevant amount of information […] search field strategies allow the use of the limited resources to a maximum benefit."
Talke et al., 2010, p. 909	"The set-up of **innovation fields** can be further understood as an integrated, overarching principle of how a firm will achieve its innovation objectives, i.e. as a unified strategy."
Kock et al., 2015, p. 542	"Defining and formulating an **ideation strategy** means that companies explicitly align their idea generation and selection activities with their innovation strategy. The formulation of an ideation strategy determines the primary boundaries for opportunity and idea searching that are consistent with the firm's strategy."

Table 6: Overview of Innovation Field Definitions

Notes:
Source: see table
Emphasis added

The underlying thesis will lean on the definition of Salomo, Talke and Strecker (2008) and enhance it: innovation fields are an instrument to structure the strategic phase of the front-end of innovation by establishing guidelines that determine the search strategy, scope, depth, and locus of innovation search by setting search boundaries. These guidelines are "related by one common theme, which can be a customer need, a core competence, a technology platform, or any combination of these" (Salomo et al., 2008, p. 561; Talke et al., 2010, p. 909). The innovation strategy is determined by the sum of innovation fields. Innovation activities such as ideas or innovation projects can be linked to innovation fields, thereby showing the alignment between activities and corporate goals and the state of the innovation pipeline.

Innovation fields provide a solution to achieve a balance between rigid process formalization in the front-end of innovation and no structure at all by offering a flexible and adaptive approach to determine and prioritize strategic innovation topics in the front-end of innovation. Accordingly, the process remains responsive and does not become stale (Adams-Bigelow, 2004, p. 549; Raisch & Birkinshaw, 2008, p. 401). In this sense, they foster ambidexterity by balancing explorative with exploitative innovation fields (Raisch & Birkinshaw, 2008, p. 401).

2.4.2 Applications and Proficiency of Innovation Fields

Although innovation fields are primarily described as serving the alignment of innovation activities with corporate objectives (Cooper et al., 2004, p. 50; Danneels & Kleinschmidt, 2001, p. 369; Laurie et al., 2006, p. 82; Salomo et al., 2008, p. 561), the concept of innovation fields offers several other types of applications that are related and take place in the front-end of innovation. These comprise lifting synergies and fostering collaboration (Gillier et al., 2010; Salomo et al., 2008), promoting portfolio extension and radical innovation (Colarelli O'Connor & Ayers, 2005, p. 23), organizing technology intelligence (Wellensiek et al., 2009, p. 3), and guiding ideation (Buggie, 2002; Perkins, 1981). Furthermore, innovation fields are described as enhancing the overall performance and innovativeness (Danneels, 2002; Salomo et al., 2008). The applications and the proficiency of innovation fields will be further elaborated in the following. The following table lists the applications and the relevant authors to provide an overview of innovation field research.

Application	Author(s)
Strategic purposes (strategy formulation, focus, portfolio management)	(Buggie, 2002; Cooper, 1984; Cooper et al., 2004; Cooper & Kleinschmidt, 2001; Crawford, 1980; Firth & Narayanan, 1996; Gillier et al., 2010; Hatchuel et al., 2001; Laurie et al., 2006; Leifer et al., 2000; Salomo et al., 2008; Talke et al., 2010)
Ideation	(Amabile, Conti, Coon, Lazenby, & Herron, 1996; Buggie, 2002; Cooper et al., 2004; Finke, Ward, & Smith, 1992; Goldenberg, Mazursky, & Solomon, 1999; Kock et al., 2015; Perkins, 1981; Rosso, 2014)
Lifting synergies	(Gillier et al., 2010; Halman, Hofer, & van Vuuren, 2003; Hatchuel et al., 2001; Hoegl & Parboteeah, 2007; Laurie et al., 2006; Pinto, 2002; Salomo et al., 2008; Talke et al., 2010)
Technology intelligence	(Hatchuel et al., 2001; Lichtenthaler, 2004; Schuh et al., 2009)
Portfolio extension	(Colarelli O'Connor & Ayers, 2005; Crawford, 1980; Laurie et al., 2006; Leifer et al., 2000; Salomo et al., 2008)
Proficiency: enhancing performance and innovativeness	(Cooper et al., 2004; Danneels, 2002; Hatchuel et al., 2001; Salomo et al., 2008; Schuh et al., 2009)

Table 7: Literature Overview about Innovation Field Research

Notes:
Source: own representation

Several companies report applying innovation fields in the front-end of innovation, such as 3M, Procter & Gamble, Medtronic, UPS, Tefal and Wella (Clausen, Geschka, & Krug, 2012; Hatchuel et al., 2001; Laurie et al., 2006; Salomo et al., 2008). It is interesting to note that all of these papers report the application of innovation fields at a business level, whereas these studies do not touch upon the individual level, such as whether innovation fields are used by employees and – if so – how they are applied. Thus, this is an interesting notion to be followed up.

2.4.2.1 Application of Innovation Fields for Strategic Purposes

Using innovation fields for strategic purposes can have three different foci: they are described as a means for (1) formulating and communicating the strategy to employees, (2) focusing on specific selected innovation topics and (3) balancing the portfolio of innovation activities. All three foci are elaborated in the following.

Strategy Formulation

> "Few businesses of any economic, social, or political significance can be optimally managed today without strategic planning. Perhaps the groups most appreciative of the advent of strategic planning are those engaged in producing new products. […] Today's strategic planning techniques enable any firm to give its product development function an integrated, goals-oriented character. The key element in accomplishing this orientation is a spin-off of the strategic planning process. It consists of a set of policies and objectives designed to guide new product development." (Crawford, 1980, p. 3)

According to a study by Cooper, Edgett, and Kleinschmidt (2004), innovation strategies are established in the majority of companies, although there is a lack of converting this strategy into practicable guidelines (Cooper et al., 2004, p. 51). Innovation fields provide strategic orientation to companies that need to innovate. Hambrick and Fredrickson (2001) define a strategy as comprising *arenas* and *vehicles*: the arenas define *where* the activities will take place, while the vehicles answer the question of *how* they will be reached (Hambrick & Fredrickson, 2001, p. 53). Talke, Salomo and Rost (2010) discover similarities to innovation fields: "[b]oth elements can be found within the concept of innovation fields. Firms focusing on innovation fields have to define fields along certain specification criteria, and have to 'live' this specification by setting up actual fields with related projects […]" (Talke et al., 2010, p. 909). This notion compares well to Buggie (2002), who suggests establishing upfront *success criteria* in order to structure the front-end of innovation previous to the ideation phase. The sum of these criteria constitutes the innovation strategy, driven by capabilities or technology (Buggie, 2002, p. 11f.). With this kind of strategic orientation, innovation fields help to explore new businesses and new markets while being dismantled from existing businesses (Talke et al., 2010, p. 909).

With innovation fields, upper management can express the *strategic intent* for a certain path to follow (Leifer et al., 2000, p. 33) or prioritize and launch *strategic initiatives* for new growth areas (Laurie et al., 2006, p. 88; Salomo et al., 2008, p. 561) that are "derived by upcoming trends, customer needs and internal capabilities" (Laurie et al., 2006, p. 84). Hatchuel, Le Masson and Weil (2001) state that innovation fields give orientation where dominant designs are missing (Hatchuel et al., 2001, p. 4) by defining a product vision that is embedding product families to give rise to architectural innovation (Hatchuel et al., 2001, p. 11; Henderson & Clark, 1990). Therefore, innovation fields can be described as an instrument to create a multi-faceted innovation strategy (Talke et al., 2010, p. 909).

As important as formulating the strategy, is its communication. The sharing of strategic goals in the front-end of innovation is seen as favorable for success (Poskela & Martinsuo, 2009, p. 680; Zhang & Doll, 2001, p. 108). For Zollo and Winter (2002), this is called *knowledge codification*. Through sharing knowledge and making it transparent, a common understanding is reached that clarifies the search scope (Zollo & Winter, 2002, p. 342). Furthermore, transparency helps to classify *isolated initiatives* and to stop them, if they do not fit with the organization's competencies (Salomo et al., 2008, p. 564). A study by O'Cass et al. (2014) shows that it is essential to translate this strategy into other functional areas of the company for the strategy to work properly (O'Cass, Heirati, & Ngo, 2014, p. 867).

Besides using innovation fields for the formulation of strategy, innovation fields enable concentration and focus, or as Drucker (1985) states: "innovation requires knowledge, ingenuity and, above all else, focus" (Drucker, 1985, p. 72).

Focusing Innovation Activities

Following Cooper, Edgett and Kleinschmidt (2004), "focus is the key to an effective NPD strategy" (Cooper et al., 2004, p. 51). Innovation fields allow dedication and a focus on specific topics with allocated budget and thus can be an instrument leading to more new product successes, hence separating successful from less successful companies (Cooper, 1984, p. 161; Cooper et al., 2004, p. 51; Crawford, 1980; Salomo et al., 2008, p. 561). Cooper (1984) compares having a focus with "having a rifle rather than a shot gun approach to new products" (Cooper, 1984, p. 161).

Being focused fosters other advantages and applications for innovation fields: it allows the discovery of synergies and related projects, as well as guidance for ideation and acts as evaluation and selection criteria to the existing portfolio (Cooper, 1984, p. 161; Cooper et al., 2004, p. 52). For new growth areas or diversification purposes, a strong degree of focus enables a long-term perspective beyond the existing portfolio (Laurie et al., 2006, p. 87) and engagement of the board of management (Laurie et al., 2006, p. 90). Additionally, it helps departments and employees to concentrate on dedicated innovation activities and to see the big picture rather than centering around functional details (McKee, 1992, p. 235).

In a study by Firth and Narayanan (1996) on new product strategies in large companies with a "substantial proportion of revenue [...] derived from sales in a single industry" (Firth & Narayanan, 1996, p. 335), companies without a clear focus are exposed to greater risks (Firth & Narayanan, 1996, p. 343; Salomo et al., 2008, p. 564). On the other hand, the focus cannot be overly-rigorous or productivity decreases. "[…] [B]oth very highly focused and very disparate efforts will be on average less productive than those that are 'appropriately' focused and 'appropriately' diverse" (Henderson & Cockburn, 1996, p. 42). Organizations that focus overly-rigorously cannot lift synergies, while unfocused organizations have a hard time harmonizing activities (Henderson & Cockburn, 1996, p. 42). Thus, the right balance has to be found between clear goals and sufficient freedom for new sparks. As outlined in Chapter 2.3.3.6, an effective innovation strategy focuses but considers the balance between explorative and exploitative innovation.

Portfolio Management

The third characteristic for innovation field application for strategic purposes is the management of the new product portfolio. Within an innovation context, two types of portfolios can be distinguished: the innovation and project portfolio. The innovation portfolio – set in the front-end of innovation – contains early ideas and its objective is to develop these ideas into concepts and choose the most preferential concepts to be tranformed into an innovation project. By contrast, a project portfolio contains mature innovation projects, dedicated to be developed into new products that can be introduced to markets and customers. Its objective is the mitigation of risk through spreading between low- and high-risk projects (Mathews, 2010, p. 31). Cooper et al. (2001) summarize the task of portfolio management as follows:

> “Portfolio management for new products is a dynamic decision process wherein the list of active new products and R& D projects is constantly revised. In this process, new projects are evaluated, selected and prioritized. Existing projects may be accelerated, killed, or deprioritized and resources are allocated and reallocated to the active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependencies among projects, and multiple decision makers and locations.” (Cooper, Edgett, & Kleinschmidt, 2001, p. 3)

First, innovation fields can enable knowledge transfer through creating transparency of innovation activities (Hatchuel et al., 2001, p. 11; Henderson & Cockburn, 1996, p. 33). Second, they provide an overview of the progress in the innovation fields, thereby showing the overall pipeline potential as well as the potential of each field. Furthermore, they facilitate task coordination for each of the fields. Gillier, Piat and Truchot (2010) introduce software that supports the display of the innovation field portfolio and its according activities in the front-end of innovation and state that the transparent representation of such a portfolio steers interests and knowledge gaps. With such a tool, the impact of each innovation field can be measured towards the corporate goals (Gillier et al., 2010, p. 889).Third, innovation fields provide a first strategic filter for idea and concept evaluation. This ensures the match of ideas to the innovation strategy (Buggie, 2002, p. 12). With a set of determined innovation fields, the front-end portfolio can be balanced out between different criteria (exploration/exploitation, existing business/new business, risk/return) that are strongly linked to ensure the alignment with corporate goals (Chao & Kavadias, 2008, p. 907; Cooper, 2005, p. 25; Henderson & Cockburn, 1996, p. 34). “Using multiple criteria for specifying focus areas may also lead to a more balanced approach toward innovation, as it prevents from limiting a project’s scope to, for example, a technology focus” (Salomo et al., 2008, p. 564). Using portfolio management approaches is linked to greater overall performance (Chao & Kavadias, 2008, p. 907; Cooper et al., 2004, p. 50).

2.4.2.2 Application of Innovation Fields for Ideation

> "Suppose someone were to look for something that had no shape; to pursue something that didn't move; to find something that wasn't in any real place; to dig for something that wasn't under anything; to look out for something that had no appearance. That someone might be searching for ideas." (Perkins, 1981, p. 130)

Innovation fields are described as providing guidance for ideation, connecting innovation strategy and idea generation. Having determined innovation fields enables employees to search for valuable ideas in these fields (Buggie, 2002, p. p.12). Innovation fields help to set the search scope, depth, and locus and deliver guidelines for innovation search, linked to corporate goals and strategy (Mootee, 2011).

At Nortel, the management established an *idea sandbox* to identify new product ideas in a specific field (Leifer et al., 2000, p. 29). Goldenberg, Mazursky and Solomon (1999) introduce *templates* as a "facilitative tool that channels the ideation process, enabling the person to be more productive and focused" (Goldenberg et al., 1999, p. 200). Kock et al. (2015) recommend setting up an *ideation strategy* to align the corporate goals with ideation and focus resources on specific ideas. In their study, this ideation strategy is defined as innovation fields, setting specific search boundaries (Kock et al., 2015, p. 542).

Two underlying principles can explain why innovation fields guide ideation. Perkins (1981) puts the first mechanism like this: "[…] in inventive thinking, one looks in different 'conceptual places' – for instance, by taking different approaches to a problem that might lead to quite different solutions" (Perkins, 1981, p. 131). Thus, innovation fields help to channel the search scope and offer structure to the unstructured ideation process. With the help of innovation fields, a variety of combinations can be considered similar to Altshuller's TRIZ approach (Altshuller, 1999; Goldenberg et al., 1999, p. 204). They offer different perspectives and detect patterns by combining current product innovations with new information, such as trends or customer needs (Goldenberg et al., 1999, p. 202).

The second mechanism is the so-called *restricted scope* mechanism triggered through thinking in constricted topics (Goldenberg et al., 1999, p. 205). Finke, Ward, and Smith (1992) explain this mechanism as follows:

> "Restricting the ways in which creative cognitions are interpreted, encourages creative exploration and discovery and further reduces the likelihood that the person will fall back on conventional lines of thought. Restricting the categories, for example, forces people to think about conceptual implications in more atypical ways, which tends to promote creative discovery […] and can force one to consider novel interpretations of those concepts." (Finke et al., 1992, p. 32; Perkins, 1981)

Employees are challenged to think and search beyond existing knowledge and routes (Perkins, 1981, p. 100). In other words: "creativity loves constraints" (Mayer, 2006). Asking the right questions and setting the right constraints is key to develop new ideas with higher creativity (Coyne, Clifford, & Dye, 2007, p. 72; Kock et al., 2015, p. 543). There are contradictory results about the degree of freedom in creative search for ideas. While Amabile et al. (1996) argue that freedom is one success factor for successful creativity (Amabile et al., 1996, p. 1166), a recent study by Rosso (2014) shows that *product constraints*, such as requirements or customer need constraints, are beneficial for the results (Rosso, 2014, p. 578). However, the study also reveals that the constraints cannot be overly-strict and that only product constraints have a positive impact while process constraints indicate less favorable outcomes (Rosso, 2014, p. 579). In a second study, Amabile (1998) highlights that the explication of strategic goals enhances creativity (Amabile, 1998, p. 81).

With innovation fields, employees do not follow a greenfield strategy but know exactly where to search (Perkins, 1981, p. 132). Finding the right balance for constraints versus freedom and channeling ideation relates to success: with defined innovation fields, the created ideas have a greater average quality, and there is a larger number of advanced ideas, while the total number of ideas is less than in a study without predefined fields (Goldenberg et al., 1999, p. 208; Perkins, 1981, p. 142f.). Cooper, Edgett and Kleinschmidt (2004) confirm that more successful companies help employees to focus on their search for ideas (Cooper et al., 2004, p. 52). By setting search boundaries and balancing between new areas previously unknown to the company and refining existing knowledge domains, innovation fields guiding innovation can facilitate reaching ambidexterity (Kock et al., 2015, p. 541).

2.4.2.3 Application of Innovation Fields for Lifting Synergies

Galbraith and Schendel (1983) define synergies as "economies gained from interactions and combinations of individual elements that separately cannot contribute as greatly as when grouped" (Galbraith & Schendel, 1983, p. 156). In an innovation context synergies are the possibility for a company to profit from current expertise and capabilities in order to define new products that are more successful in the market than those without synergies (Calantone et al., 2006, p. 413; Cooper & Kleinschmidt, 1987, p. 182). If used as a strategical instrument in NPD, synergies are shown to influence new product success (Henard & Szymanski, 2001, p. 373). Discovering synergies with innovation fields means to "contribute to a more continuous stream of significant innovations or even entire new business compared with innovation activities that only focus on single products or businesses" (Salomo et al., 2008, p. 561; Talke et al., 2010, p. 909).

Therefore, innovation fields must be well integrated into the corporation and communicated to grasp the existing knowledge on similar activities (Laurie et al., 2006, p. 87) and "assemble the right portfolio of capabilities, business processes, systems, and assets that are required to deliver products and services" (Laurie et al., 2006, p. 82). New innovation fields can profit from the expert knowledge and infrastructure within the corporation, while similar activities on existing projects can lead to fruitful synergies, e.g. new distribution channels (Laurie et al., 2006, p. 84).

Having innovation fields allows corporations to establish portfolio and platform thinking and thereby managing and coordinating activities within each innovation field to uncover knowledge spillovers or economies of scope and collaboration possibilities while reducing costs, time and risk (Halman et al., 2003, p. 150;

Henderson & Cockburn, 1996, p. 33; Pinto, 2002, p. 29). Henderson and Cockburn (1996) give an example:

> "Economies of scope exist if the work of a group of peptide chemists is potentially relevant to a wide range of applications, and can be utilized in any one of them without diminishing its usefulness to the others. Benefits of diversity may also arise if discoveries made in one program stimulate the output of another through cross-fertilization of ideas or other forms of knowledge spillovers." (Henderson & Cockburn, 1996, p. 35)

Put differently, Hatchuel, Le Masson and Weil (2001) call this the organization of divergence. When elaborating on an innovation field, interdependencies have to be uncovered and acted upon. The repeated usage of the created knowledge facilitates faster development, enhances future profits and enables new product ideas through further improvement of said knowledge (Hatchuel et al., 2001, p. 11).

Jonash and Sommerlatte (1999) claim a new *operating principle* for R&D including the definition of innovation fields and the exploitation of existing knowledge by uncovering synergies. Faster learning can be ensured through organizational networks that deliver real-time know-how. Furthermore, through the codification of network participants, projects can be set up with the right set of skills (R. S. Jonash & Sommerlatte, 1999, p. 2). The shared resources in related projects or topics within an innovation field can lead to better efficiency (Salomo et al., 2008, p. 565). They can also encourage cross-functional collaboration while having a greater goal in mind or inspire new solutions by bringing together different aspects of knowledge (Gillier et al., 2010, p. 887; Pinto, 2002, p. 30f.; Salomo et al., 2008, p. 565).

Gillier, Piat and Truchot (2010) show that inter-firm collaboration with innovation fields led to new and cross-functional results:

> "Energy and mobility appear as a broad IF in which various concepts (e.g., new energy systems producer, new power supplies, new business models) and knowledge (e.g., new micronanotechnology, data on customer habits) can emerge. […] For some partners, it was a good opportunity to explore new technology (e.g., lithium-ion rechargeable batteries, new materials). For others, it was a chance to provide new functionalities for their existing products (e.g., electric car with innovative services, electric skis)." (Gillier et al., 2010, p. 891)

Hoegl and Parboteeah (2007) underline this finding by highlighting that domain-relevant skills can bloom when teamwork quality is high, leading to greater efficiency and putting contrasting perspectives together (Hoegl & Parboteeah, 2007, p. 152). Thus, having different perspectives and individual backgrounds when elaborating an innovation field increases overall results. With innovation fields, information can be made accessible to everyone and potential suggested synergies on the topic can be made transparent (Hoegl & Parboteeah, 2007, p. 152). Furthermore, creativity is heightened through the different perspectives when collaborating, leading to superior solutions (Thompson, 2003, p. 102). In explorative settings, collaboration in innovation fields can lead to new skill sets and expertise that did not previously exist (Gillier et al., 2010, p. 887).

2.4.2.4 Application of Innovation Fields for Technology Intelligence

Technology intelligence can be described as the "systematic identification of future chances as well as threats for the company" (Wellensiek et al., 2009, p. 2). These chances and threats usually appear in the form of so-called *weak signals* (Ansoff, 1976, p. 129) *or seeds of change* (Glassey, 2009, p. 321). Weak signals are defined as "elements announcing further (r)evolution" (Glassey, 2009, p. 321). These are pieces of information taken from discussions with colleagues, news from the internet, scientific papers or the occurrence of start-ups that are neither interpreted nor related to other pieces of information. Through evaluating these pieces of information, combining them with other signals and interpreting them in the organization's context, they gain value and turn into "key intelligence findings" or trends that can predict future events, technological advancements or significant societal changes (Ashton & Stacey, 1995, p. 101). Technology intelligence covers the management of unpredictable changes in the environment and foresight for future developments that are yet to be seen. Companies establish dedicated processes for identifying, managing and interpreting these weak signals for the creation of innovation and ultimately gaining competitive advantage over other companies (Liebl & Schwarz, 2010, p. 313). Having an established system for technology intelligence in place allows heightened attention to change, providing guidance and lead during uncertain and turbulent times through the ability to react rapidly to upcoming threats or chances (Ansoff, 1976, p. 143).

The process of technology intelligence can be divided into single steps: the definition of information demand, the search for information, the assessment of innovation and the communication of innovation [...]" (Schuh et al., 2009, p. 2). Lichtenthaler (2004) further distinguishes the search for information between "an undirected perspective of technology intelligence, the so-called scanning, and a directed perspective, the so-called monitoring" (Lichtenthaler, 2004, p. 332). Scanning can be done without a specific goal and implies activities like visiting fairs, watching the news, or picking up information from various sources. On the other hand, monitoring is more directed and comprises the search for weak signals, which is guided by a specific search scope such as the observation of new technological trends and their advancements (e.g. 3D technology).

According to Lichtenthaler (2004), insufficient technological intelligence is one of the factors why companies fail, given that employing dedicated units for technology intelligence might not be sufficiently efficient to cover all the relevant information. Much rather, there should be an organized process for technology detection, integrating and linking all perspectives and prior knowledge in the corporation (Lichtenthaler, 2004, p. 332).

Innovation fields can play a distinct role in supporting technology intelligence. The definition of innovation fields determines the search scope and the information demand. This demand is derived from the technological competencies of a corporation and its innovation strategy (Schuh et al., 2009, p. 5). Therefore, innovation fields determine the information need and act as a first filter for evaluation (Lichtenthaler, 2004, p. 336). Each innovation fields needs to be monitored regarding relevant weak signals. This information gathering helps to assess the field and its potential opportunities. By collecting weak signals for each innovation field, more precise search directions and even first ideas are made apparent, determining further elaboration efforts (Schuh et al., 2009, p. 4f). Thus, this type of activity gives a first indication of the potential of the innovation field or even its possible termination: "some [...] could reach very rapidly the shores of development others will call for much longer maturing, and some of them will never give birth to any product" (Hatchuel et al., 2001, p. 11).

Thus, innovation fields can be an instrument to provide an overview of technology intelligence for the innovation strategy, while showing transparency regarding which information is gathered for each innovation field. With innovation fields, weak signals can be gathered, evaluated and communicated, thus leading to a significant increase of efficiency in technology intelligence (Lichtenthaler, 2004, p. 346; Schuh et al., 2009, p. 7). Additionally, being in possession of a front-end portfolio comprising innovation fields helps to detect upcoming trends, and customer needs not yet captured by innovation fields. Therefore, using innovation fields for technology intelligence can guide the creation of new innovation fields through detecting gaps (Mootee, 2011; Schuh et al., 2009).

2.4.2.5 Application of Innovation Fields for Portfolio Extension

According to Crawford (1980), Laurie, Doz and Sheer (2006), Leifer, McDermott and Colarelli O'Connor (2000), and Salomo, Talke and Strecker (2008), innovation fields can also be used to foster portfolio extension or diversification.

While one of the objectives of a target business area can be portfolio diversification (Crawford, 1980, p. 5f.), Laurie et al. (2006) describe the task of *new growth platforms* as being exclusively to "search for opportunities between and beyond the scope of existing businesses" (Laurie et al., 2006, p. 85). O'Connor & Ayers (2005) call them *white* and *grey spaces* that can be found between or beyond the current portfolio without momentary activities or resource allocation (Colarelli O'Connor & Ayers, 2005, p. 24). With innovation fields being purposefully chosen and derived from corporate goals and strategy, traditional product or research streams can be opened up to find entirely new business opportunities or markets (Salomo et al., 2008, p. 561). Leifer et al. (2000) also state that for diversification purposes, a strategic intent in the form of innovation fields has to be communicated to encourage employees to think beyond existing products, customers or technologies and to seek new chances or ideas that could lead to the next major discovery (Leifer et al., 2000, p. 33). Hatchuel et al. (2001) support this thought by claiming that there needs to be *divergence* in order to derive the best outcomes from an innovation field, meaning thinking in different connected and unconnected directions (Hatchuel et al., 2001, p. 11).

Detecting strategic gaps, exploring *white spaces* or elaborating on *new growth platforms* can be an critical enabler for radical innovation and portfolio, skill and business extension and is essential for sustainable firm success, especially in the increasingly shifting environment (Colarelli O'Connor & Ayers, 2005, p. 24; Danneels, 2002, p. 1095; Leifer et al., 2000, p. 33; Salomo et al., 2008, p. 564). With innovation fields, topics beyond the current scope of business can be determined intentionally, thereby prioritizing adjacent thoughts and ideas.

Using innovation fields can help to overcome the *local search bias* (Rosenkopf & Nerkar, 2001) because the mission can be set to search beyond known technology and business. Searching beyond the scope of existing businesses calls for a systematization through innovation fields (Laurie et al., 2006; Leifer et al., 2000) that are strategically driven. Colarelli O'Connor and Ayers (2005) describe two types of models to facilitate portfolio extension and potentially radical innovation. Both models demand the set-up of innovation fields to cluster and coordinate the innovation activities. Companies pursuing the so-called *strategy-driven* model define *technology-market domains* in early and emerging businesses, implying the transfer of existing technology in new markets (Colarelli O'Connor & Ayers, 2005, p. 8). The second model is called *executive-driven* and unfolds through the creation of *growth platforms* that bundles ongoing initiatives that either lie between business units or affect several ones likewise (Colarelli O'Connor & Ayers, 2005, p. 8; Salomo et al., 2008, p. 561). These predefined fields enable corporations to renew themselves by setting up new *strategic assets* (Danneels, 2002, p. 1115).

2.4.2.6 Innovation Field Proficiency

Studies suggest that the existence of innovation fields distinguishes between good and bad performing companies (Cooper et al., 2004, p. 51; Salomo et al., 2008, p. 561). In a study by Cooper (2004), 70% of the best performing companies used innovation fields, compared with only 50% of the worst performing companies (Cooper et al., 2004, p. 51). Thus, more successful organizations use innovation fields more often than organizations that do not have them implemented (Schuh et al., 2009, p. 3). There are two proficiency-related indicators, namely innovativeness and performance, that innovation fields are said to increase.

It is reported that innovation fields increase innovativeness at the company level. Innovativeness is a crucial factor in new product development. "Innovative products present great opportunities for firms in terms of growth and extension into new areas. Significant innovations allow firms to establish competitively dominant positions, and afford new comer firms an opportunity to gain foothold in the market" (Danneels, 2002, p. 357). Innovation fields help companies to explore new business streams leading to greater innovativeness and provide a further indication of greater success (Salomo et al., 2008, p. 562). "Pursuing thematically related projects can also help realizing new combinations across projects, thereby stimulating innovativeness" (Salomo et al., 2008, p. 564). Hatchuel et al. (2001) suggest that the use of innovation fields helps to build more innovative products. Through establishing *design strategies*, "an intellectual framework that gives birth to new architectures, to the identification of new market values, hence to innovative products", recurring innovation can be fostered (Hatchuel et al., 2001, p. 4).

Besides the study of Salomo et al. (2008), measuring the proficiency of innovation fields is not in the focus of other studies. Furthermore, these studies do not illuminate the circumstances or contextual factors leading to greater performance or innovativeness for the organization when using innovation fields.

The next chapter introduces the research question of this thesis and the applied research framework.

Conclusion

- Innovation fields are an instrument to structure the strategic phase of the front-end of innovation by establishing guidelines that determine search strategy, scope, depth, and locus of innovation search by setting search boundaries.
- Innovation fields foster ambidexterity by deliberately balancing explorative and exploitative search for innovation and innovation activities.
- The innovation strategy is determined by the sum of innovation fields.
- Innovation fields can be used for strategic purposes, lifting synergies, portfolio extension, technology intelligence, and ideation.
- Innovation fields are described as enhancing the overall performance and innovativeness.

2.5 Research Questions

The following chapter derives and presents the research questions for the underlying thesis and the research framework derived from organizational learning theory.

Contextual Ambidexterity and Innovation Fields

In Chapter 2.1.2, it was outlined that organizations need to be ambidextrous to remain competitive and ensure long-term survival and competitive advantage (Gibson & Birkinshaw, 2004; Levitt & March, 1988). Innovation fields – as described above – structure the strategic phase of the front-end of innovation and determine the search strategy, scope, depth, and locus of the innovation search by setting search boundaries. All innovation fields taken together comprise the innovation strategy of an organization.

In a paper from Wei, Yi and Guo (2014), it is argued that previous research does not offer an answer concerning how organizations can adapt their portfolios to reach ambidexterity (Z. Wei, Yi, et al., 2014, p. 833). Several other papers also outline the neglect of described solutions for corporations to build up ambidexterity (Cantarello et al., 2012, p. 45; Judge & Blocker, 2008, p. 922). In this context, innovation fields can be an instrument that supports the strive for ambidexterity, balancing exploitative innovation fields with explorative innovation fields and making this selection transparent for the organization.

Additionally, innovation fields can support the cognitive paradox between explorative and exploitative thinking, manifesting different *thought worlds* for these activities (Raisch et al., 2009, p. 687). It is argued that ambidexterity requires dynamic and constant alignment of activities. Using innovation fields turns alignment away from a static into a dynamic process through the flexible reconfiguration of strategic innovation topics (Raisch et al., 2009, p. 688).

While innovation fields are implemented at the organizational level, they are used at the individual level. Employees apply them to execute the innovation strategy. The same is true for ambidexterity: "[A]lthough ambidexterity is a characteristic of a business unit as a whole, it manifests itself in the specific actions of individuals throughout the organization" (Gibson & Birkinshaw, 2004, p. 211). Raisch et al. (2009) extend this notion by adding that ambidexterity at the individual level is affected by the personality, prior knowledge and organizational elements (Raisch et al., 2009, p. 687). As outlined in Chapter 2.1.3, an emphasis is placed on contextual ambidexterity, where organizational elements such as the strategic orientation and organizational context play a crucial role.

Only a few studies describe what influences reaching ambidexterity (Gibson & Birkinshaw, 2004, p. 210; Raisch & Birkinshaw, 2008, p. 380; Raisch et al., 2009, p. 693; Siggelkow & Levinthal, 2003, p. 653). One of the few papers addressing the notion of innovation ambidexterity in relation to contextual factors and environmental factors was written by Jansen et al. (2006), who examine the prerequisites for exploration and exploitation. While it has been stated as crucial to follow both explorative and exploitative innovation activities, it needs to be analyzed how corporations manage these types of activities, especially in the front-end of the innovation (Jansen et al., 2006, p. 1661).

To date, the notion of ambidexterity has only been investigated for innovation projects, innovation performance and firm performance (He & Wong, 2004; Jansen et al., 2006; Tushman & O'Reilly, 1996). What has not been investigated thus far is how ambidexterity is reached at the front-end of innovation and what contextual factors influence ambidexterity in the front-end of innovation. Besides the question of how innovation fields are used at the front-end of innovation, the contextual factors influencing the application remain unknown.

Structuring the Front-End of Innovation

Despite its acknowledged importance, only little empirical research has been conducted regarding the front-end of innovation, (J. Kim & Wilemon, 2002a; Koen & Bertels, 2010; Markham, 2013; Verworn et al., 2008). In the editorial "Identification and Consideration of Emerging research questions", Kahn et al. (2003) perceive the front-end of innovation as a topic for further research especially for the topic strategy (Kahn et al., 2003, p. 193). Keupp et al. (2013) address strategic management of innovation as an important topic for future research (Kahn et al., 2003, p. 193; Keupp et al., 2013, p. 368). According to Kock et al. (2015), the front-end of innovation strongly differs from later stages in the innovation process, and the later stages are much better understood. Thus, research on the front-end of innovation is essential for a better understanding, making it a relevant field for future studies (Kock et al., 2015, p. 541).

Regarding innovation fields, research is even scarcer, as the majority of literature on innovation fields is conceptual. There are only two recent empirical papers known about the performance of innovation fields, namely the studies by Salomo et al. (2008) and Talke et al. (2010) (Salomo et al., 2008; Talke et al., 2010). In their study, Salomo et al. (2008) focus on the impact of an innovation field orientation towards innovativeness and firm performance, while Talke et al. (2010) study how top management diversity influences performance and innovativeness in the process of establishing innovation fields. For Schuh, Orilski and Wellensiek (2009) there is a lack of structures and typologies for the topic of innovation fields (Schuh et al., 2009, p. 3), while for Salomo et al. (2008) "research on corporate innovation fields is rare, and the characteristics and consequences of such an orientation remain a puzzle", especially the "aspects […] included in innovation field orientation" (Salomo et al., 2008, p. 569). Hatchuel, Le Masson & Weil (2001) demand more scholarly attention towards their definition by identifying companies that apply innovation fields and conducting research on them (Hatchuel et al., 2001, p. 13).

Particularly the formulation of Salomo et al. (2008) translates into the need to understand the role of contextual factors for innovation field application. Although the study by Salomo et al. (2008), measures the proficiency of innovation fields, it does not illuminate the circumstances or contextual factors leading to greater performance or innovativeness for the organization. Several companies report applying innovation fields in the front-end of innovation, such as 3M, Procter & Gamble, Medtronic, UPS, Tefal, and Wella

(Clausen et al., 2012; Hatchuel et al., 2001; Laurie et al., 2006; Salomo et al., 2008). It is interesting to note that all of these papers report the application of innovation fields at the organizational level, whereas they disregard the individual level, such as the question of how innovation fields are applied at the individual level and the role of contextual factors.

Research Questions

Nonetheless, to date, no study has distinguished (1) the different types of applications for innovation fields and (2) the role of contextual factors influencing the application and proficiency. Thus, the objective of this thesis is to determine the role of contextual factors influencing innovation field application and their proficiency in a corporate context.

The following research questions will be examined:

1. How and why do perceived contextual factors influence the intended application of innovation fields?
2. How and why do perceived contextual factors influence the perceived proficiency of innovation fields?

Several notes have to be made regarding the framing of these two research questions. First, examining the way in which innovation fields are applied and the role of contextual factors calls for **how and why** questions and an explorative research design. This will be further elaborated in the next chapter. Second, **perception** indicates the subjective experience and judgement of contextual factors and proficiency of innovation fields. This is especially important since it is assumed that people behave according to their subjective perceptions rather than factual reality (Ferris & Kacmar, 1992, p. 94; Lewin, 1936, p. 19). Third, **intention** captures the tendency to use innovation fields and not the actual usage, which is due to the chosen case and its context, described in Chapter 3.4.2. Fourth, **contextual factors** refer to the main influencing factors derived in Chapter 2.1.4. These factors establish the basis of the research framework, introduced in the next section. Fifth, this dissertation explores the previously-outlined types of applications as well as the general intention to use innovation fields. Sixth, the research questions focus on the **individual level** as opposed to the firm level. Thus, the research on innovation fields concentrates on the application of innovation fields on the individual level.

Research Framework

In Chapter 2.1.4, general contextual factors influencing ambidexterity have been outlined, namely the strategic orientation, organizational context, and external environment. Strategic orientation is described as the organization's strategic positioning to generate aligned behavior and prioritization regarding either the customer (market)[13], competitors or technology (Gatignon & Xuereb, 1997, p. 78). Organizational context refers

[13] Market and customer orientation are understood as tantamount terms and they describe long-term-oriented and pro-active behavior to gather all relevant information on customers including latent needs to provide superior value to customers (Slater & Narver, 1998, p. 1004).

to “the systems, processes, and beliefs that shape individual-level behaviors in an organization” (Gibson & Birkinshaw, 2004, p. 212; Raisch & Birkinshaw, 2008, p. 391). The external environment describes the external complexity and uncertainty towards, e.g. the market, technology, and competitors (Tidd, 2001, p. 175). As outlined above, the underlying dissertation analyzes contextual factors, and thus structural factors will be omitted from further investigation.

To answer the above-described research questions, these contextual factors will be incorporated into a broad research framework to explore their role regarding innovation field application. The underlying thesis will explore, which of these factors are relevant for the front-end of innovation, specifically for the application of innovation fields. Figure 16 shows the research framework.

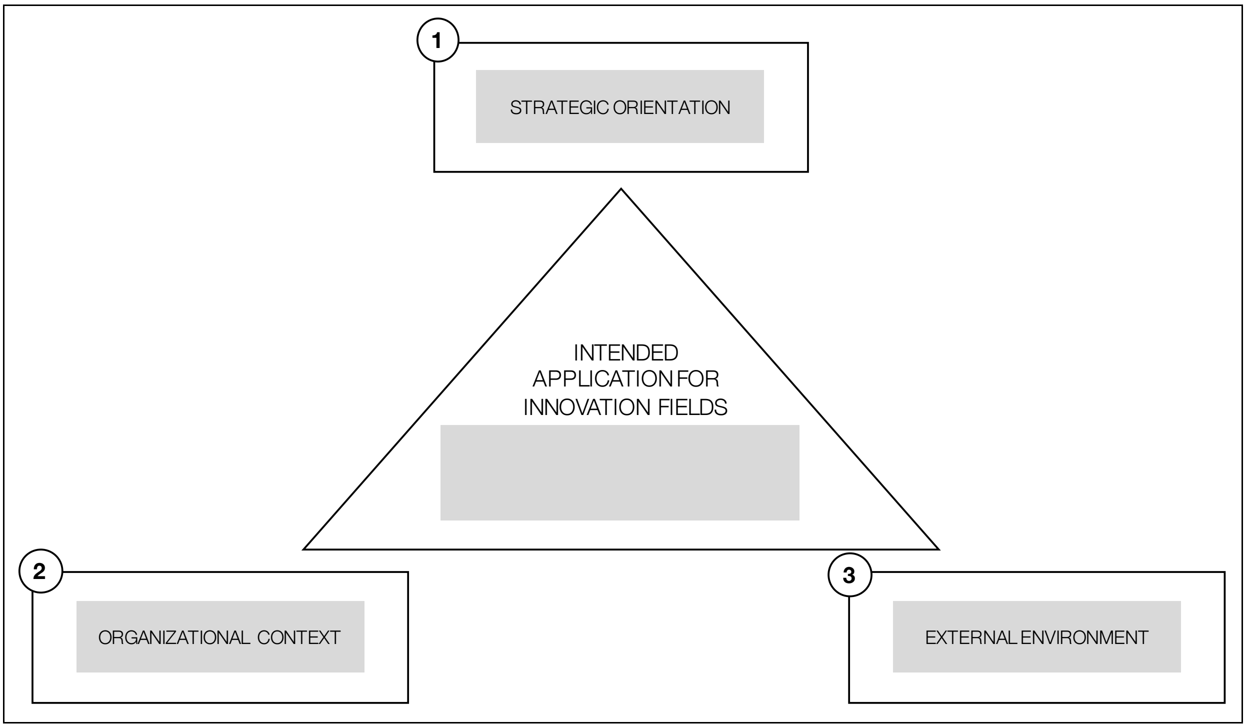


Figure 16: Derived Research Framework from Organizational Learning

Notes:
Source: own representation

The next chapter will introduce different research designs and identify the best-suited research methods to answer the research questions.

3 Methodology

The objective of this chapter is to find the best-suited type of research method for the research question in place. Therefore, the primary research types – qualitative and quantitative research – are explained and discussed. There are several advantages and disadvantages of qualitative and quantitative research, leading to the conclusion that a mixed-methods approach using both research types outweighs the disadvantages of each singularly-applied research type. Furthermore, the different kinds of case studies are discussed and contrasted. In a final step, the best-fitting research design is derived from the research question and detailed.

STRUCTURE OF CHAPTER 3: METHODOLOGY

Figure 17: Chapter Overview of Methodology

Notes:
Source: own representation

3.1 Types of Research

Typically, two types of research can be distinguished: **qualitative** and **quantitative research**. "In general, *quantitative research* specifies numerical assignment to the phenomena under study, whereas *qualitative research* produces narrative or textual descriptions of the phenomena under study" (Vanderstoep & Johnston, 2008, p. 7).

These two different types of research will be presented, explained in the Chapters 3.1.1 and 3.1.2 and compared in Chapter 3.1.3.

Qualitative and quantitative research are linked to opposing world views and perceptions of reality and truth. Qualitative research is often related to the so-called *constructivist worldview*, a social explication of reality, meaning that truth/reality is created (Vanderstoep & Johnston, 2008, pp. 166, 172). Subjective meanings are formed and agreed upon in a social and historical context, while being influenced by interaction and norms, thus constructing reality and truth (Creswell, 2013, p. 8). "The researcher's intent is to make sense of (or interpret) the meanings others have about the world" (Creswell, 2013, p. 8).

By contrast, quantitative research, is related to a *positivist* or *post-positivist worldview*, meaning that the truth is objective, observable and simply *out there* (Vanderstoep & Johnston, 2008, pp. 166, 172). "Thus, developing numeric measures of observation and studying the behavior of individuals becomes paramount for a postpositivist" (Creswell, 2013, p. 7).

3.1.1 Qualitative Research

Denzin and Lincoln (2011) describe qualitative research as an analytical method to make the environment evident. Through qualitative research, the environment can be observed through instruments such as interviews, notes or any other kind of document or recording. Through this type of data collection, the research subjects are studied in their natural context, "attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 2011, p. 3). Vanderstoep and Johnston (2008) add the notion that qualitative research is analyzing processes, asking how something happened rather than only analyzing results and the frequency of events, making the meaning and background of events predominant in qualitative research (Vanderstoep & Johnston, 2008, p. 165). Thus, qualitative studies offer rich descriptions and fruitful explanations of the question being researched (M. B. Miles & Huberman, 1994, p. 4).

Creswell (2013) stresses the research design in his definition:

> "Qualitative research begins with assumptions and the use of interpretive/theoretical frameworks that inform the study of research problems addressing the meaning individuals or groups ascribe to a social or human problem. To study this problem, qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is both inductive and deductive and establishes patterns or themes." (Creswell, 2013, p. 44)

He further describes the key features of qualitative research, such as:

- collecting data directly at the place where the problem or phenomenon occurs;
- putting the researcher at the center of the analysis without relying on previously-published guiding questions from other authors;
- using multiple methods and sources of data, e.g. interviews, observations, or documents;
- using inductive and deductive rationales to build up patterns and themes from the data;
- focusing on the interpretation of the participants rather than the interpretation of the researcher;
- allowing responsive method design, shifting the focus of the research, the questions, or the participant base during study; and
- trying to create a holistic view of the topic under study (Creswell, 2013, p. 46ff.).

Qualitative research is often used when the topic under study is of an explorative nature. Reasons for explorative research can be (1) studying a particular group of people, (2) discovering variables that are not apparent or easy to assess, (3) developing an in-depth understanding of the topic under research, (4) understanding the setting and context around the research topic and not only the research issue itself and (5) following up or preceding quantitative research in order to uncover structures that deliver explanations in and for causal relations (Creswell, 2013, p. 48).

The type of data used in qualitative research is most prominently interviews, notes, any kind documents, recordings and even pictures or videos, hence any form of non-numerical data (Denzin & Lincoln, 2011, p. 3; Saunders, Lewis, & Thornhill, 2009, p. 151).

3.1.2 Quantitative Research

Quantitative research started to emerge from usage in psychology in the late-19th century in the form of experiments. Today, the two main methods of quantitative research are surveys and experiments (Creswell, 2013, p. 12).

A survey is the numerical characterization of perspectives or trends by using a questionnaire with a pre-selected set of participants (sample) drawn from a population with the aim of generalizing findings from the sample. On the other hand, an experiment examines whether and how a procedure has consequences in a specific setting (Creswell, 2013, p. 12).

A deductive approach is usually connected to quantitative research, meaning that hypotheses are generated up-front and tested. It is frequently used in business and management research context and corresponds to "[…] who, what, where, how much and how many questions" (Saunders et al., 2009, p. 144). These questions imply usage for both explorative and descriptive use cases. Data is analyzed either descriptively (in percentages or quantiles) or with inferential statistics (Saunders et al., 2009, p. 144).

3.1.3 Comparison of Qualitative and Quantitative Research

Qualitative and quantitative research differs in a variety of categories, as displayed in the following. They contrast in (1) purpose and focus, (2) type of data, (3) analysis and (4) scope of inquiry. Table 8 summarizes the differences.

Category		Qualitative	Quantitative
1)	Purpose & focus	Describing phenomena, discovery of themes	Predicting phenomena, discovering causal relationships between variables; generalizability
2)	Type of data	Non-standardized, narrative data, text	Standardized, numerical data
3)	Analysis	Mostly inductive analysis of text, identification of categories and conceptualization in themes	Mostly deductive analysis of data points; statistical analysis, use of diagrams
4)	Scope of inquiry	Broad themes	Specified questions

Table 8: Main Differences between Qualitative and Quantitative Research

Notes:
Source: Saunders et al., 2009, p. 482; Vanderstoep & Johnston, 2008, pp. 7, 167

While qualitative research is about describing a phenomenon, discovering broad themes and grasping a comprehensive view of the research question in place, quantitative research is about predicting and discovering causal relationships (Vanderstoep & Johnston, 2008, p. 167). Furthermore, the main goal of quantitative research is the generalization of findings. Data from qualitative research is non-standardized and analyzed through inductive approaches, while quantitative data is standardized, mostly numerical and analyzed through deductive approaches.

„A deductive approach is a process of reasoning that flows from a theory/hypothesis to systematic empirical observation to conclusion. An inductive approach is a process of reasoning that follows a reverse path—observation precedes theory, hypothesis, and interpretation. Qualitative researchers let the data 'speak' to them and try to avoid going into a study with a preconceived idea of what they will find." (Vanderstoep & Johnston, 2008, p. 168)

Qualitative and quantitative research methods have both strengths and weaknesses, which are compared in the following table.

Characteristic	Quantitative research	Qualitative research
Advantages	Large sample reflecting the population, generalizability given[1]	Rich and detailed understanding of topic[1]
	Statistical validity[1]	Narrative description of sample[1]
	Popular method in various disciplines[2]	Understanding of complex processes and events[2]
	Cost-effective and quick method[2]	More concrete and vivid descriptions, more compelling to read[3]
	More honest answers through granted anonymity[2]	Higher chance to reach the right respondents[2]
Disadvantages	Superficial[1], limitation of broadness[4]	Small sample size[1]
	Insufficient understanding of underlying factors[1], no additional insights possible	Limited generalizability[1]
	Risk of misunderstanding the questions[2]	Reality distortion through Interviewer's effect[2]
	Not appropriate for how & why questions[2]	Enormous work intensity[3]

Table 9: Overview of Benefits and Disadvantages of Qualitative and Quantitative Research

Notes
Source: 1:Vanderstoep & Johnston, 2008, p. 7, 2: Vissak, 2010, p. 379, 3: M. B. Miles & Huberman, 1994, p. 4, 4: Saunders et al., 2009, p. 144

The advantage of quantitative research is the use of larger samples, resulting in a better generalizability (Vanderstoep & Johnston, 2008, p. 7). Surveys are a common method of quantitative research since they permit collecting a considerable supply of data from a large participant's base. The comparison of answers is easier through the standardization of questions. Furthermore, due to the popularity of surveys, this research method is fairly easy to understand and pitch to executives for approval (Saunders et al., 2009, p. 144). Additionally, in the academic world, research containing quantitative data is easier to publish in higher-ranked journals (Vissak, 2010, p. 379), while at the same time often being less expensive and time-consuming than qualitative research (Saunders et al., 2009, p. 144). The probability of obtaining honest answers from the individual respondents is higher through the granted anonymity of surveys (Vissak, 2010, p. 375).

On the downside, quantitative studies are described as being superficial and not generating a broad understanding about the studied object (Vanderstoep & Johnston, 2008, p. 8). Besides, quantitative studies have a limitation of broadness. This means that there is a limit to the number of items that can be used in a questionnaire (Saunders et al., 2009, p. 144). Since data in surveys is standardized, there is no possibility of understanding underlying factors or gaining additional insights from the data. Moreover, thoughts and feelings cannot be expressed as freely as in qualitative research. This leads to the conclusion that quantitative research is less suited for complex topics as well as for how and why questions (Vissak, 2010, p. 374). Companies that are being asked to participate in quantitative research via surveys mostly do not receive any useful results from quantitative studies when they are published. Since companies often receive surveys on a daily basis, they may not wish to participate, leading to a low response rate and survivor bias (more successful companies tend to fill out surveys more than less successful ones). Alternatively, respondents might give random answers to complete the survey quicker, especially if it is anonymous. Finally, the risk of not understanding survey questions is perceived higher than in qualitative interviews (Vissak, 2010, p. 374).

Qualitative studies are detailed, in-depth and offer a rich understanding of the object under study, not only answering the *what*, but also the *how* and *why* (Vanderstoep & Johnston, 2008, p. 8). The sample is described more narratively, disclosing complicated contexts and making it possible to study very complex processes or events. Qualitative research provides more compelling stories embellished with rich details, than the matter-of-fact reporting from quantitative research (M. B. Miles & Huberman, 1994, p. 4). When conducting interviews, the chance is higher to reach the right respondents and to collect more information. Additionally, the chance that more answers are given is higher in personal interviews. Furthermore, it is easier to skip survey questions in an online questionnaire compared with a personal interview (Vissak, 2010, p. 374).

The advantages of quantitative research are the disadvantages of qualitative research: due to the small samples, no general conclusions can be drawn (Vanderstoep & Johnston, 2008, p. 8). With qualitative research, the researcher's integrity of results can be questioned (M. B. Miles & Huberman, 1994, p. 4). Interviewees could see their experiences, opinions, and decisions from a more beneficial perspective which in turn can lead to reality distortion, also known as the interviewer's effect (Vissak, 2010, p. 376). Further disadvantages of qualitative research comprise the significant work intensity of the process of data collection, the processing as well as coding and the possibility of being overwhelmed due to the amount of data collected (M. B. Miles & Huberman, 1994, p. 4). Due to time constraints, only a limited number of interviews can be conducted (Vissak, 2010, p. 375). This is another downside since the participants have to be chosen wisely due to the limited number of cases. Inappropriate sampling will distort the object under research or not reveal all perspectives on it.

Both quantitative and qualitative methods have advantages as well as disadvantages and have different effects on the outcome. One option to neutralize the weaknesses of each singularly-applied method is to mix these methods, namely using both quantitative and qualitative methods (Saunders et al., 2009, p. 154).

3.2 Mixed-Methods

To outbalance the disadvantages of each singularly-applied research method, so-called **mixed-methods** emerged in the 1980s and have gained increasing attention in recent years (Creswell, 2013, p. 14). The notion of mixed-methods – which involves combining qualitative and quantitative research – is known under several other terms, such as *multi-methods* (Brannen, 1992), *multi-strategy* (Bryman, 2004) and *mixed methodology* (Bryman, 2006, p. 97f.; Tashakkori & Teddlie, 2003). This chapter will describe the definition of mixed-methods, the varying types of mixed-methods and their advantages and disadvantages.

3.2.1 Definition and Types of Mixed-Methods

Denzin (2012) refers to mixed-methods research as an "[…] inquiry that focuses on collecting, analyzing and mixing both quantitative and qualitative empirical materials in a single study or series of studies" (Denzin, 2012, p. 82; Rocco, Bliss, Gallagher, & Pérer-Prado, 2003, p. 19). Mixed-method research not only refers to data collection, but also to using different perspectives and analytical methods (B. Johnson, Onwuegbuzie, & Turner, 2007, p. 123).

For Miles and Huberman (1994) mixed-methods provide a powerful combination of advantages of both research methods. Quantitative research provides generalizable findings that are statistically valid while qualitative research enhances these findings through further insights on the often multi-faceted context and background (M. B. Miles & Huberman, 1994, p. 42).

Although it is agreed that mixed-methods research helps to develop an in-depth understanding of the phenomenon in question, there has been an extensive debate about mixing qualitative and quantitative research, since they rely on different paradigms (Denzin, 2012, p. 82; B. Johnson et al., 2007, p. 112).

The *pragmatist worldview* is often used when combining both qualitative and quantitative research. It is not devoted to a specific view of truth and uses whatever works for the research question in place. "The pragmatist researchers look to the what and how to research based on the intended consequences – where they want to go with it" (Creswell, 2013, p. 10). This debate has recently been disposed as philosophical, and a pragmatic way forward is needed (Denzin, 2012, p. 82).

Mixed-methods research is mainly used to enhance the broadness and astuteness of comprehension and validation (B. Johnson et al., 2007, p. 123). Qualitative data can support quantitative data in several ways: first, it can help the survey design through uncovering needed variables and hypothesized relations. Second, the personal communication with people can facilitate the access to participants for the survey and extend the participation base. Third, qualitative data can enrich the quantitative results by delivering additional arguments for validation or clarification of the results or by illuminating the findings (M. B. Miles & Huberman, 1994, p. 43). Qualitative research can support quantitative research by amplifying the source and means of variable relationships and offering first indications for such relationships (Vanderstoep & Johnston, 2008, p. 167).

Types of Mixed-Methods Research

Several authors have found paradigms for distinguishing the different types of mixed-methods that can be applied. Saunders makes a distinction between *mono methods* and *multiple methods*, using one single or several methods for collecting data. Multiple methods are increasingly encouraged, especially in business and management research (Curran & Blackburn, 2001; Saunders et al., 2009, p. 151).

Multiple methods can be divided into multi-method and mixed-methods research designs. Multi-method designs use distinct data collection types, albeit within the set of either qualitative or quantitative methods. Thus, when using multi-methods, quantitative and qualitative methods are not fused. On the other hand, as the term suggests, mixed-methods use both quantitative and qualitative techniques for data collection. They can be either sequential or parallel (Saunders et al., 2009, p. 152).

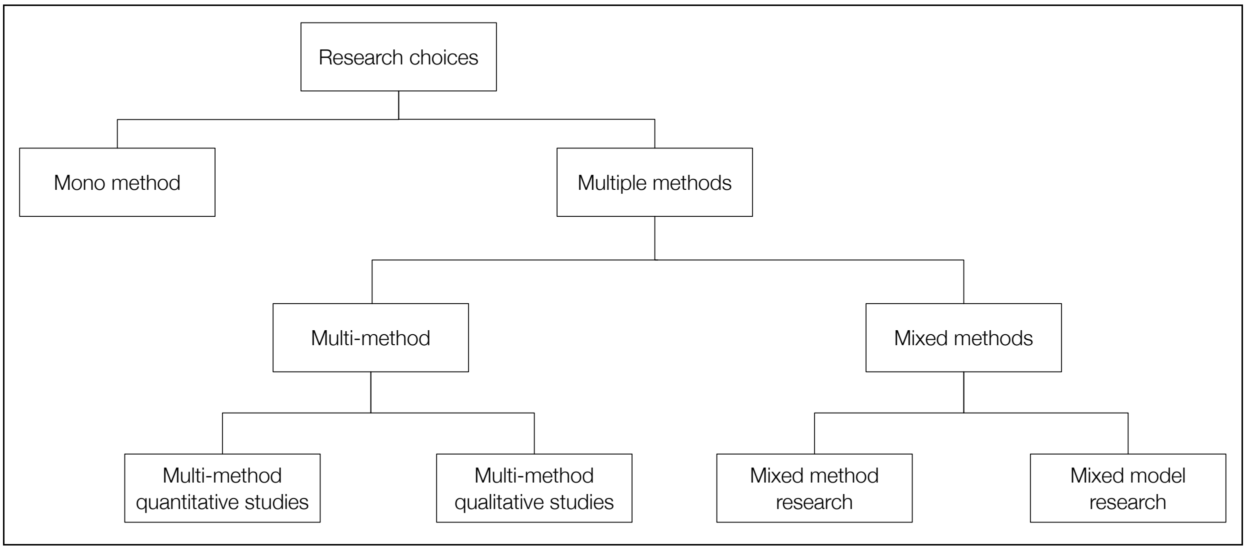


Figure 18: Overview of Research Method Choices

Notes:
Source: Saunders et al., 2009, p. 152

Miles and Huberman (1994), as well as Creswell (2013) describe these parallel and sequential research designs for mixed-methods approaches. When integrated, four different types can be differentiated (Creswell, 2013, p. 15; M. B. Miles & Huberman, 1994, p. 43f.):

- Design 1: In *convergent parallel mixed-methods,* qualitative and quantitative data is constantly obtained in a consolidated manner over the course of the case. Convergent parallel mixed-methods try to create a holistic picture of the research question by applying qualitative and quantitative methods in parallel and integrating the information to understand the *bigger picture*.
- Design 2: *Undulated parallel mixed-methods* are coined through the permanent collection of qualitative data, which is supported by a longitudinal survey at different points in time.
- Design 3: For the *exploratory sequential mixed-methods,* qualitative and quantitative data is collected in turns starting with an exploratory qualitative study from which a quantitative study is developed. Another cycle of qualitative data can then extend the meaning of the quantitative data collected. The qualitative research is used to specify instruments and variables for the quantitative study.
- Design 4: The *explanatory sequential mixed-methods* also alternate qualitative and quantitative data, starting with a quantitative survey. The results then point to a particular topic that needs a

deeper understanding, for which qualitative data is used. Another quantitative study can then test the developed hypothesis with a larger participant base. The qualitative study is conducted in order to explain the quantitative results in more detail.

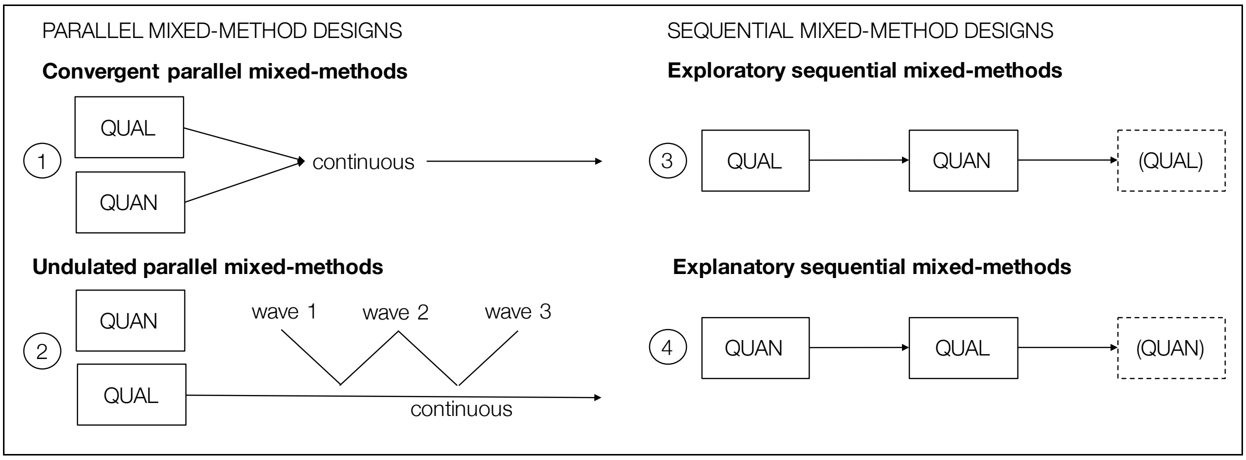


Figure 19: Types of Mixed-Method Research Designs

Notes:
Source: Creswell, 2013, p. 219; M. B. Miles & Huberman, 1994, p. 44

Besides these designs, Johnson, Onwuegbuzie and Turner (2007) distinguishes between qualitative or quantitative-dominant mixed-method research and pure mixed-methods, whereby qualitative and quantitative research hold equal rank (B. Johnson et al., 2007, p. 124).

A study by Bryman (2006) showed that in cross-sectional studies, the most commonly-used methods within qualitative research are semi-structured interviews, while for quantitative approaches it is questionnaires and structured interviews (Bryman, 2006, p. 102; Saunders et al., 2009, p. 153). In mixed-method approaches, almost half of the articles (41.8%) used a survey combined with qualitative interviews (Bryman, 2006, p. 104).

3.2.2 Reasons and Advantages of Applying Mixed-Methods

It is undeniable that the combination of qualitative and quantitative methods in research designs has been used increasingly frequently in recent times (Bryman, 2006, p. 97). There are several reasons for using mixed-methods, as explained in the following.

First of all, using different methods caters to differing needs within the research study, such as exploring a theme with qualitative research methods and validating the results with quantitative data (Saunders et al., 2009, p. 153). In addition, helpful information for interpretation is collected, and new ways to look at the phenomenon are created (Jick, 1979, p. 608f.; Vissak, 2010, p. 380).

Through mixed-methods research, more sophisticated research questions can be examined and more difficult phenomena can be studied (Vissak, 2010, p. 380; Yin, 2014, p. 66), since the amount of information is more profound (Yin, 2014, p. 66) and is said to be more robust and trustworthy, given that the broadness of data is enhanced by using different methods (Greene, Caracelli, & Graham, 1989, p. 258ff.). Using mixed-methods can bolster conclusions drawn from the study (Vissak, 2010, p. 380). By using a mixed-method research design, two diverse perspectives of qualitative and quantitative data are used (Creswell, 2013, p. 217; Jick, 1979, p. 608f.; Saunders et al., 2009, p. 153), providing a holistic understanding of the phenomenon and complementarity (Greene et al., 1989, p. 258ff.). Through the usage of both types of data, biases can be overcome, such as the respondent bias (Vissak, 2010, p. 380) and through triangulation the quality of the research is increased (Denzin, 1989, p. 207; Greene et al., 1989, p. 258ff.; Vissak, 2010, p. 380). Furthermore, inconsistencies can be unveiled, different theories integrated or new research questions uncovered by using different research methods in one study (Greene et al., 1989, p. 258ff.; Jick, 1979, p. 608f.). Besides, depending on the anonymity, through quantitative studies "[…] representative sample members, as well as outlying (i.e., deviant) cases […]" can be discovered for further qualitative inquiries (B. Johnson et al., 2007, p. 115). While interpreting qualitative data, quantitative results can help to generalize qualitative data and set it into perspective (B. Johnson et al., 2007, p. 115). Quantitative results can also uncover cause-effect relations that were not previously evident. Furthermore, it can "keep researchers from being carried away by vivid, but false, impressions in qualitative data, and it can bolster findings, when it corroborates those findings from qualitative evidence" (K. M. Eisenhardt, 1989, p. 538).

On the other hand, qualitative results help to create quantitative measures and instruments by unveiling patterns and initial hypotheses to be further analyzed (Creswell, 2013, p. 217; Greene et al., 1989, p. 258ff.; B. Johnson et al., 2007, p. 115). Quantitative data can be clarified, validated and enriched with qualitative data (Creswell, 2013, p. 217; B. Johnson et al., 2007, p. 115). "The qualitative data are useful for understanding the rationale or theory underlying relationships revealed in the quantitative data or may suggest directly theory which can then be strengthened by quantitative support […]" (K. M. Eisenhardt, 1989, p. 538). Bryman (2006) compiled several reasons for applying mixed-methods research mentioned in papers that he studied, which are shown in Table 10.

Reason	**Explanation**
Triangulation	Applying different research methods or data sources to validate findings
Methods building upon each other	A second research method can build upon the first one such as building hypotheses through qualitative research that is then tested with quantitative research or selecting the most interesting cases from quantitative research for in-depth qualitative research
Interpretative support	Qualitative data can support the interpretation of quantitative findings and relationships
Different perspectives and complementarity	Quantitative data can unveil the macro-level, while qualitative data can deliver an in-depth perspective on the phenomenon in question. Furthermore, different aspects can be highlighted.
Clarifying inexplicable results	A second data source or research method can facilitate the explanation of contradicting or inexplicable results from the first data source of research method

Table 10: Reasons for Applying Mixed-Method Design as Research Method

Notes:
Source: Adapted from Bryman, 2006, p. 104ff; Saunders et al., 2009, p. 154

Put simply, there are various reasons supporting a mixed-methods research design, combining qualitative and quantitative data.

An especially important reason for combining qualitative and quantitative data is triangulation.

Four types of triangulation can be distinguished:

1. Triangulation of data sources
2. Triangulation of investigators
3. Triangulation of perspectives
4. Triangulation of methods (Yin, 2014, p. 120).

The most critical triangulation for mixed-methods is the triangulation of methods. Through using diverse methods, a greater validation of constructs can be ensured (K. M. Eisenhardt, 1989, p. 538). When performing data triangulation (1), "the multiple sources of evidence essentially provide multiple measures of the same phenomenon" (Yin, 2014, p. 121). Thus, method triangulation provides clarity over what the data really means by combining the perspective of qualitative interviews with the angle of the survey on a phenomenon (Saunders et al., 2009, p. 146).

3.3 Case Study Research

Mixed-methods is a research approach that can be used by itself, or it can be embedded in a case study research design. The definition of a **case study** comprises two aspects – the scope and its features – which are described as follows:

- Scope: a case study is a research design that studies a current phenomenon, also referred to as the case in detail and within its natural context when the distinction separating phenomenon and context are not clearly obvious.
- Features: a case study research is distinct through the existence of a larger number of variables to be taken into consideration than data points available. Therefore, different methods and sources of data collection are used and triangulated. Through theoretical assumptions drawn prior to data collection, the analysis and interpretation of data can be navigated (Robson, 2002, p. 178; Yin, 2014, p. 16f.).

Case studies can be a useful research strategy to gain insights into individual or organizational phenomena that are commonly used in various research areas, including the business context. With a case study, it is possible to gain a comprehensive and actual picture of the phenomenon in question, such as organizational processes (Yin, 2014, p. 4). Case studies allow extensive insights into the context of the research object and the dynamics of the context, whereby the phenomenon can be understood (K. M. Eisenhardt, 1989, p. 534).

Case studies are especially favorable when (1) how and why questions are in place, when the research is (2) an event or a set of events taking place in the present, when (3) the researcher has no control over said event (Yin, 2014, p. 14), (4) the phenomenon is of exploratory nature (Saunders, 2009, p. 146) and requires (5) a detailed characterization (Yin, 2014, p. 2f.).

Eisenhardt (1989) demonstrates the best fit for case studies as being distinctly suitable "to new research areas or research areas for which existing theory seems inadequate. This type of work is highly complementary to incremental theory-building from normal science research. The former is useful in early stages of research on a topic or when a fresh perspective is needed, whilst the latter is useful in later stages of knowledge" (Eisenhardt, 1989, p. 548f.). Vissak (2010) describes case studies as useful instrument for topics that have not drawn much research attention to them, since they do not need to rely on existing literature or preceding data and can be used for theory-building although little is known about the phenomenon (Saunders et al., 2009, p. 147; Vissak, 2010, p. 371). Cases are applicable universally since they can be used for describing, testing and generating theories (K. M. Eisenhardt, 1989, p. 535).

The type of data can be of qualitative as well as quantitative nature or combining the two kinds (K. M. Eisenhardt, 1989, p. 534). These methods involve interviews, surveys, observations, archives and document analysis (Saunders et al., 2009, p. 146). When using different types of data, overlap, and triangulation of data should be ensured. Furthermore, field notes taken can support and enhance the data and make it easier to interpret. Tetje and Scholz (2002) provide an overview of data collection methods for case studies.

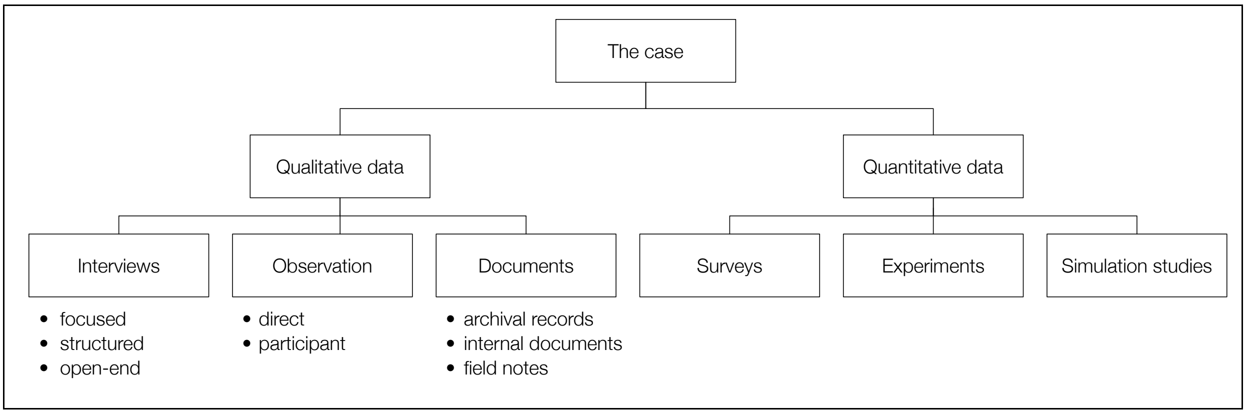


Figure 20: Data Sources in Case Study Design

Notes:
Source: own representation, based on Scholz & Tetje, 2002, p. 14

The strengths of case studies can be summed up in the following list (Vissak, 2010, p. 372ff.):

- Case studies are increasingly common in various scientific areas (Vissak, 2010, p. 379).
- They provide a higher probability of participants answering surveys (Vissak, 2010, p. 379).
- Case studies offer detailed and clearly-understandable descriptions (Vissak, 2010, p. 372)
- Data can be collected longitudinally and thus offers more insights than cross-sectional designs (Vissak, 2010, p. 372).
- Although multiple cases are preferable due to overcoming observer bias and enhancing validity, case study research gives the possibility to generalize from only one case, if the case is suitable for building theory of if there is only one unique case or one case approachable for the researcher (Vissak, 2010, p. 373).
- Case studies can analyze companies from different perspectives and offer a holistic picture about it (Vissak, 2010, p. 379; Yin, 2014, p. 19ff.).
- Case studies are very adaptable and can include more research questions or redraft existing ones (Vissak, 2010, p. 379).
- They focus on how and why questions, which are often disregarded by other research methods (Yin, 2014, p. 19ff.)

Some concerns and weaknesses have to be overcome when using case study research that are summarized in the following list:

- Case study research is described as soft, less precise and objective and – in some cases – even as unscientific (only referred to in cases with mono methods of qualitative nature) (Vissak, 2010, p. 378).
- Lack of accuracy: case study research is often described as being unsystematic and *sloppy* (Yin, 2014, p. 19ff.).
- Case studies are accused of being bias-prone due to the qualitative approach mostly used and the selection of interviewees and cases (Vissak, 2010, p. 379; Yin, 2014, p. 19ff.).
- With case study research, the generalization of results can be challenging, if taken from a single case. Therefore, no statistical generalization can be extracted from the case, and theories are difficult to corroborate (Vissak, 2010, p. 383; Yin, 2014, p. 19ff.).
- Case study research is costly and time consuming, thereby producing a enormous amount of data (Vissak, 2010, p. 383; Yin, 2014, p. 19ff.).
- Depending on the context, it is difficult to gain access to confidential information and the respondents might not reveal the truth (Vissak, 2010, p. 379).

- It is hard to find a balance between case profoundness and case range: single cases can give a very profound understanding but reduce the breadth, while the opposite is true for multiple cases (Vissak, 2010, p. 379).

To overcome the weaknesses, a mixed-methods approach is recommended. “The results obtained from quantitative research could be analyzed first and then case studies conducted and other qualitative research methods used to illustrate the conclusions or to explain some unexpected findings” (Vissak, 2010, p. 380). Furthermore, caution has to be taken concerning case and context selection as well as the choice of method and data collection. Besides, a systematic research approach should be followed, making all evidence gathered transparent and the analysis procedures understandable.

To ensure high quality of the case study research design, four criteria have to be met: construct validity, internal validity, external validity and reliability (Yin, 2014, p. 45ff.). The following table shows the definitions of these criteria and tactics to meet them within case study research design.

Criterion	**Definition**	**Case study tactic**
Construct validity	Operationalization of measures for data collection and interpretation	• Using multiple evidence sources
Internal validity	For explanatory studies: conditions underlying possible causal relationships	• Explanation building • Pattern matching • Using competing explanations and logic models
External validity	Generalizability of findings	• Theory usage in single case studies
Reliability	Repeatability of study, e.g., data collection method	• Case study database • Case study protocol

Table 11: Criteria for Case Study Design Quality

Notes:
Source: adapted from Yin, 2014, p. 45ff.

Selecting the cases is a crucial step within case study design since some variables can already be controlled for when choosing the cases. Furthermore, it also defines “the limits for generalizing the findings” (K. M. Eisenhardt, 1989, p. 537). In particular, this means that e.g., environmental variation, the corporation size or type of activity can be controlled for, as well as organization-specific settings. With this in mind, cases possess the opportunity to “shed empirical light about some theoretical concepts or principles […]” (Yin, 2014, p. 40). Accordingly, generalizations can be drawn, that go beyond the particular case in question.

Types of Case Study Designs

In general, four main types of case study designs can be distinguished. The first distinction is between single case and multiple case studies. Furthermore, depending on the context, the single or multiple cases can be either holistic (with one single unit of analysis) or embedded (with multiple units of analysis). All four types can be seen in Figure 21. The dotted lines in the pictures signal that the border between the case and the context are not sharp, but rather influence each other.

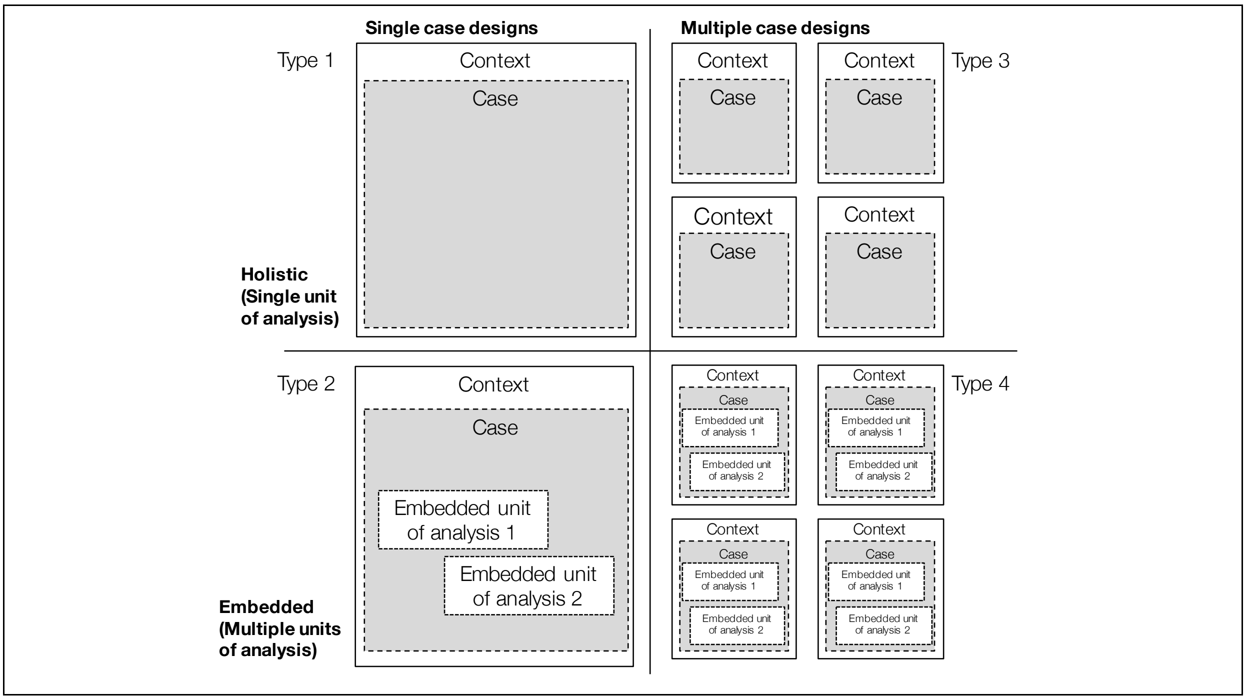


Figure 21: Overview of Case Study Designs

Notes:
Source: based on Yin, 2014, p. 50

The next section elaborates on the differences of the four case study types.

Multiple Case and Single Case Designs

There are five main rationales for choosing a single case design: the case can be either (1) critical, (2) unusual, (3) common, (4) revelatory or (5) longitudinal. The decision between a multiple- or single case design should correspond to the theoretical premises defined (Yin, 2014, p. 51):

- Critical case: theoretical propositions should clarify the conditions under which the assumptions are thought to be true. The single case thereby substantiates, imposes, or broadens existing theory.
- Unusual case: using extreme cases can help to uncover insights for normal relationships or processes and thus is generalizable to a greater extent.
- Common case: common cases unveil everyday situations, such as studying small businesses to gain insights about, e.g. innovation processes.
- Revelatory case: this type of case is useful when the opportunity occurs to gain insights where no access was previously given. This condition favors the use of a single case design.
- Longitudinal case: when given the possibility to conduct research on the same case at different points in time, gaining insights into how conditions or processes have changed, using a single case can be favorable.

A crucial factor of single case designs is the characterization of the case. In order to gain sufficient information to describe the case and obtain access to confidential information, it may be the case that the researcher analyzes the organization, for which the researcher works (Saunders et al., 2009, p. 146).

It is called a multiple case design if more than one case is used in the same study. These have been used more frequently in the past (Yin, 2014, p. 56). A study by Piekkari et al. (2009) shows the most common types of case studies in a review of international journal articles, namely as “exploratory, interview-based multiple case studies based on positivistic assumptions and conducted at a single point in time” (Piekkari, Welch, & Paavilainen, 2009, p. 577).

One advantage of using multiple case designs is that they are considered more robust than single cases. On the other hand, they are very work-intensive. One rationale for using multiple cases is the possibility to replicate the findings. When choosing cases for multiple case designs, it needs to be considered that they produce either similar or different results (Yin, 2014, p. 57). This, in turn, requires the possibility to predict the possible outcome of each of the cases and extensive preliminary theoretical considerations (Yin, 2014, p. 62).

Multiple cases can increase external validity, reduce observer bias and patterns are more clearly discovered. Furthermore, complementary perspectives can be unveiled, and correlation by chance can be eradicated (Vissak, 2010, p. 373).

Multiple cases are used for validating whether the conclusions of the first case also apply to the second case and for generalizing findings (Saunders et al., 2009, p. 146f.). They may lack information depth due to the large time effort required, causing brief descriptions and superficial conclusions (Vissak, 2010, p. 378).

When having the choice, multiple case designs may be favorable compared to single case designs, since single cases are more susceptible to failure or misinterpretation. If using a single case, a strong justification has to be made for why the single case is preferred (Yin, 2014, p. 64). Although both Yin (2014) and Eisenhardt (1989) favor multiple cases, a single case study can be preferable in terms of creating new paradigms or defying existing ones (Piekkari et al., 2009, p. 572).

Holistic and Embedded Case Designs

Regardless of the choice of a single- or multiple case design, both can either be holistic or embedded. Embedded case studies use multiple units of analysis, while holistic case designs use one single unit of analysis (Yin, 2014, p. 53). For example, when conducting research within a single organization, sub-units can be either areas, units, departments or teams (Saunders et al., 2009, p. 147). The holistic case design for a single organization equates to the study of the organization itself or regarding a specific topic as a whole (Saunders et al., 2009, p. 147).

The holistic design can be the preferred version in cases where no sub-unit can be singled out or if the theoretical propositions favor a holistic approach. The findings may be on a high level and very abstract, possibly missing out on findings that take place at the deeper level, which can be a disadvantage of such a design (Yin, 2014, p. 55). Another disadvantage is the possible change of research focus during the study, which may lead to a mismatch of the research design and the refocused research question, consequently forcing the researcher to start over again (Yin, 2014, p. 55). Embedded cases pose a strategy against a turn of research focus.

One danger when implementing an embedded design is missing holistic insights if only sub-unit analysis is taken into account (Yin, 2014, p. 55). However, “subunits can often add significant opportunities for extensive analysis, enhancing the insights into the single case” (Yin, 2014, p. 56). For multiple case designs, the choice between embedded or holistic designs depends on the research questions and the type of event or phenomenon under research (Yin, 2014, p. 62).

3.4 Research Design Rationale

A research design answers the questions of (a) what questions to conduct research on, (b) what data is interesting, (c) how to collect it and lastly, (d) how to analyze the results (Yin, 2014, p. 29).

From the previous comparisons of qualitative and quantitative research and the different types of case studies, it is now relevant to link the different research methods to the research question in place. What has been learned thus far is that mixed-methods are preferable over any single type of research method and that case study research is especially well suited to analyze the context of a complex phenomenon and related how and why questions to create a holistic picture.

3.4.1 Embedded Single Case Study Design

The research purpose is to ascertain how and why perceived contextual factors such as strategic orientation, organizational context and external environment influence the intended application and perceived proficiency of innovation fields in the front-end of innovation. Since the research questions are how and why questions, a case study is the most suitable research design. Yin (2014) explains that case studies are also well suited for complex phenomena like organizational processes (Yin, 2014, p. 4). As innovation fields are an instrument to structure the strategic phase of the front-end of innovation, this creates another strong argument to use a case study research design. Furthermore, in order to grasp perceived contextual factors and in regard to broader topics, case study research is a preferred approach (Yigitcanlar, Sabatini-Marques, Da-Costa, Kamruzzaman, & Ioppolo, 2017, p. 2).

Innovation fields are applied in organizations, which implies that the unit of analysis can only be the individuals in one single company. Regarding the choice of such a company, it is preferred that innovation fields play a crucial role for the future success of the business. This implies the selection of companies with a high innovation rate and company divisions that do not have an immediate link to the market to receive feedback, such as R&D divisions. Besides, it would be desirable to have the possibility to accompany such an organization during the process of implementation of innovation fields.

As highlighted by Eisenhardt (1989), when selecting a case, some variables can already be controlled for (K. M. Eisenhardt, 1989, p. 537). As shown in Chapter 2, innovation fields vary in their definition and terminology. In order to answer the research questions, it is crucial to study innovation fields in a context with one common definition of innovation fields to draw comparisons, which can best be ensured with a single case study. On the other hand, the applications of innovation fields will be elaborated in dependence of contextual factors such as strategic orientation, organizational context, and external environment, demanding variety in these factors. This is favorable in the case of analyzing multiple units in one corporation. Taken together, these circumstances call for an embedded single case design of type two.

Yin (2014) highlights that mixed-methods can be a good choice to pose more complicated research questions and in the case of embedded case designs it may even be implied as such:

> "embedded case studies may rely on holistic data collection strategies for studying the main case and then call upon surveys or other quantitative techniques to collect data about the embedded unit(s) of analysis. In this situation, other research methods are embedded within case study research" (Yin, 2014, p. 66).

Using mixed-methods can strengthen the results and counteract against weaknesses of single cases through methodical triangulation (Rocco et al., 2003, p. 19).

For the explorative nature of this research, a sequential mixed-methods approach is chosen:

Case study of a single organization

↙↘

Qualitative interviews with departments   Quantitative study with employees

Figure 22: Mixed-Methods within an Embedded Single Case Study Design

Notes:
Source: Yin, 2014, p. 50

To sum up, derived from the research questions, an embedded single case study with a mixed-methods approach is chosen. The mixed-methods approach is an exploratory sequential mixed-methods approach, starting with qualitative research followed by quantitative research. Both research designs are found in relevant innovation literature is presented in the following.

Embedded Single Case Study Designs in Innovation Management

Several papers use single case designs in the discipline of innovation management.

Edwards (2007) examines crisis events in innovation projects using an in-depth longitudinal qualitative study of a UK-based partnership program. To obtain a detailed overview of the activities, relations and dynamics of the project teams, qualitative data, respectively archival records, 35 face-to-face interviews and informal conversations, were gathered over a timespan of two years (Edwards, 2007, p. 397).

Murray, Papa and Cuozzo (2016) analyze the impact of innovations belonging to the internet of things with a mixed-methods approach using a qualitative document analysis including financial statements, documents as well as reports and quantitative project calculations carried out for a single company (Murray, Papa, Cuozzo, & Russo, 2016, p. 347f.).

Michelfelder and Kratzer (2013) study how and why the combination of strong and weak ties performs better than other types of collaboration. They carry out an in-depth explorative single case study with an R&D collaboration as an extreme case, where both forms of ties co-exist and can be analyzed. Three qualitative data sources were used during this case: (1) focused individual interviews, (2) direct observation and (3) press and print material, which was primarily used for triangulation purposes (Michelfelder & Kratzer, 2013, p. 1165f.).

Mixed-Methods Research Designs in Innovation Management

Several recent papers in high-ranked peer-reviewed journals in the innovation management discipline use mixed-methods, such as Vicente-Oliva, Martínez-Sánchez and Berges-Muro (2016), who analyze factors enhancing the outcomes in R&D collaborative projects using a mail survey with 69 companies and a focus group with semi-structured questionnaires (Vincente-Oliva, Martínez-Sánchez, & Berges-Muro, 2016, p. 10f.).

Furthermore, Cortmiglia, Ghezzi and Frank (2016) examine business model innovation and the causal connection towards strategy preparation through a two-step sequential mixed-methods approach, using a quantitative survey as a first step, followed by a multiple case study with four companies (Cortimiglia, Ghezzi, & Germán Frank, 2016, p. 419).

Colombo, D'Adda and Pirelli (2016) inspect the participation of new technology-based companies in partnerships and the role that venture capital (VC) plays in those partnerships. The proposed hypotheses are built with the help of theoretical papers and interviews led with eight managers of VC firms, which are then backed up with a large-scale econometric analysis using a database (Colombo, D'Adda, & Pirelli, 2016, p. 362).

3.4.2 Case Selection and Description

For the underlying thesis, a company was selected that accounts for the aforementioned rationales. The case itself and the case context are presented in the following.

Case Description

The subject of analysis are employees of a corporate R&D division within a large, multinational, integrated high-tech company with 350,000 employees[14] headquartered in Germany. The scope of this corporation varies from B-2-B products in the automotive, energy, building, automation, and industry sector to B-2-C products in medical technology and consumer goods.

The customer base thus comprises OEMs, large private firms, and end customers. The company is split up into different business divisions, covering the aforementioned product areas. The corporate R&D division comprises 22 departments attributed to six research units, three of them mainly covering technology-oriented research (technology research area) and three covering system-oriented research (system research area). System-oriented research primarily comprises research regarding the design and construction of components and products for the business divisions, while the technology research area is mainly occupied with the discovery, technical configuration, and implementation of new technologies to new or existing

[14] Associate numbers were modified due to confidentiality reasons

products. One exception in the system research area is Unit 2: Software Systems. This unit primarily applies and develops new software for all business divisions and products.

System Research Area
Unit 1: Mobility Systems
Unit 2: Software Systems
Unit 3: Consumer Goods & Building Technology

Technology Research Area
Unit 4: Materials & Sensors
Unit 5: Components & Simulation
Unit 6: Manufacturing Technologies

Each department "holds strategic and operational control over its business(es)" (Galunic & Eisenhardt, 1996, p. 259). The departments are "distinguished according to product, market (i.e., nature of end-user), and technological dimensions" (Galunic & Eisenhardt, 1996, p. 259). Each department can modify its procedures, routines and management approach for innovation and is thereby autonomous in using newly-implemented management models or adapted routines. Overall, the corporate R&D division employs approximately 1,300 employees.

Although only one organization is studied, it covers various industries allowing for sufficient variance over the reflected factors of the framework, while having the same understanding of innovation fields. This holds strong importance in this particular study to analyze the perceived proficiency and intended application of innovation fields ceteris paribus the definition aspects. This setting also helps to "control for corporate-, industry- and country-specific differences that might have otherwise masked significant effects" (Jansen et al., 2006, p. 1671).

Furthermore, within the corporate R&D division, innovation fields were implemented in March 2013, creating a unique possibility to analyze innovation field application at the stake of introduction, and "under particularly insightful and illuminating circumstances" (De Massis, Frattini, & Pizzurno, 2013, p. 15). Since the introduction of innovation fields, the employees of the six different research units have been working with innovation fields to a different extent, which causes interesting variance in the data.

Additionally, since the focus on innovation is naturally given in an R&D context, thus rendering the front-end of innovation particularly important, the corporate R&D division is a well-suited research subject. Moreover, the distance to the market is vast, resulting in difficulties of insights into customers and their needs and opinions, which makes it necessary to pursue a better technological foresight continuously.

Context Description

In 2011, a new mission for the corporate R&D division was implemented proclaiming that no new technological developments should be missed in the future. A concept focusing on the systematization of the front-end of activities as key to fulfill this mission was developed. Up until 2012, the front-end of innovation was unstructured and without prioritization.

The concept of innovation fields was developed in early 2012 after consultation with the upper management, and it was integrated into the general NPD process after final approval at a board meeting at the end of 2012.

The new product development at the R&D division encompasses the "definition of innovation fields, the generation, prioritization, selection and development of commercially promising ideas until release of a project" (internal document, 2012). Although the R&D division undertakes basic research activities, the definition of the NPD expresses the clear intention for commercialization. Hence, for the subject of analysis, successful commercialization of their innovation activities is the objective, which can be seen from the self-conception of innovation and their work:

> “the commercially successful implementation of an idea in the market. [The corporate R&D division] is seeking innovation on technologies, processes, techniques, tools, methods as well as new components, products, and systems. Hereby [the company] considers the benefits of markets and customers and, if required, the necessary business models." (internal document, 2012)

Although R&D activities rather focus on invention, the objective of the corporate R&D division is the commercialization of ideas, thus innovation (see Chapter 2.2.1 for differentiation of innovation and invention).

The definition of an innovation field was set as follows for the entire corporate R&D division:

> “An innovation field […] is defined as technical or non-technical guiding rails with which ideas with […] (high strategic fit) are systematically generated. Innovation fields can have a duration of up to several years. They are defined by a clear combination of use case and applied technology. Innovation fields shall be defined [on department level] and above [strategic innovation programs of the whole R&D division] […] as long as they fit into the general […] strategy. […] Innovation fields are the communicated innovation strategy for all employees.” (internal document, 2012)

Furthermore:

> “Innovation fields can be defined top down by the board of management, the R&D board, unit managers based on […] strategic considerations or where demands are defined by the business [divisions]. Innovation fields can also be defined bottom up through aggregation and evaluation of weak signals […]” (internal document, 2012)

Innovation fields are considered the first phase of the stage-gate-related front-end of innovation within the corporate R&D division (internal document, 2012). Weak signals and scientific partnerships can be linked to these fields. Furthermore, ideas can also be linked to innovation fields. For the development of ideas, so-called *technical* and *practical* studies have to demonstrate the theoretical and practical feasibility of the idea. After a successful practical study and the commitment of an internal customer (a business division), the start of development (SOD) begins with the set-up of a research project. Along each phase of the front-end of innovation, scanning and monitoring are tasks continuously supporting the research work through collecting weak signals and observing trends within innovation fields.

The following figure shows the front-end of innovation in detail:

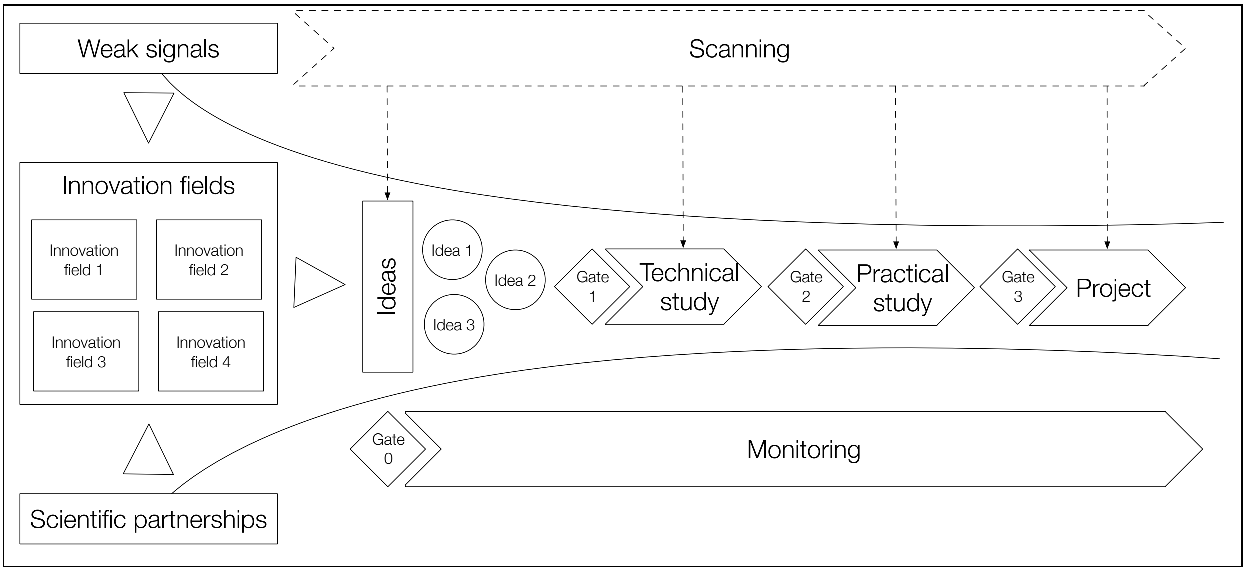


Figure 23: NPD process of the Corporate R&D Division

Notes:
Source: own representation, internal source
Names of stages and gates have been changed out of confidentiality reasons

The rollout of innovation fields was started in early 2013. The department leaders were informed about innovation fields and their definition and purpose and they were asked to create and submit the innovation fields for their department within one month's notice. From September to November 2013, meetings with all departments were held to clarify the definition and purpose of innovation fields and to offer support.

An internal online information system for innovation management was used to store innovation fields, start, and link innovation activities, ideas, and weak signals and to store scientific contacts. For this purpose, a dedicated innovation field module was programmed for the online information system.

A timeline showing the development of innovation fields at the research subject is depicted below.

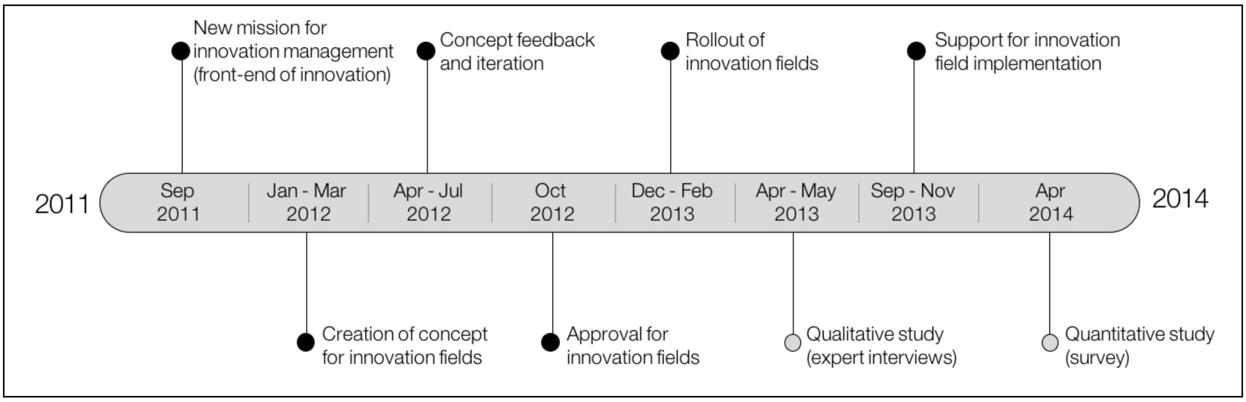


Figure 24: Timeline for Implementation of Innovation Fields

Notes:
Source: own representation

3.4.3 Applied Research Design

There are several rationales why the chosen corporate R&D division is a suitable research object for the underlying research question. Firstly, the case is a *common* case, offering profound insights into the processes and procedures of an organization. Secondly, the context of the study is revelatory, "having an opportunity to observe and analyze a phenomenon previously inaccessible […]" (Yin, 2014, p. 52). Furthermore, "the more complex and contextualized the objects of research, the more valuable the case study approach is regarded to be" (Scholz & Tetje, 2002, p. 4).

Due to the short timeframe between the introduction of innovation fields and the conduction of the empirical research (see Figure 24), this thesis focuses on the intended applications for innovation fields and their perceived proficiency.

There are different reasons for the usage of mixed-methods in the underlying research. The aspect of triangulation (overcoming biases) (Denzin, 1989, p. 207) and complementarity (reaching a holistic understanding of the analyzed phenomenon through utilization of various research methods) as well as reaching convergence in the analysis of the research object favor using mixed-methods. A further aspect is that of development, using the first method to prepare the second (Greene et al., 1989, p. 258ff.). Furthermore, when applying a single case, the application of mixed-methods is preferable (Yin, 2014, p. 66). The mixed-method approach utilized in this thesis entails two steps. It is a sequential and exploratory mixed-methods design "[alternating] two kinds of data collection, beginning with exploratory fieldwork, leading to the development of quantitative instrumentation, such as questionnaire" (M. B. Miles & Huberman, 1994, p. 41ff.).

Interviews are a substantial part of case study evidence, shedding light on information that otherwise would not have been revealed. In the context of research in a business setting, qualitative research is able to unveil perceptions. Especially explorative qualitative research highlights discovery, which is of the essence with the underlying research questions (Paluch & Wunderlich, 2016, p. 2425).

However, they also have to be treated with caution and substantiated with other forms of data (Yin, 2014, p. 113). First, qualitative interviews with each department will be conducted, enabling *unit triangulation*: "in other words, […] contrasting the perspectives of multiple organizational units" (Piekkari et al., 2009, p. 582).

"Yet another type of case study interview is in fact the typical survey interview, using a structured questionnaire. The survey could be signed as part of an embedded case study […] and produce quantitative data as part of the case study evidence […]" (Yin, 2014, p. 112). This can occur if, e.g. an organization is the case and a survey among the staff is one source of evidence. This survey would be treated like any other survey, although it would be set in relation to other sources of evidence when analyzing the overall results (Yin, 2014, p. 113).

The following figure shows the selected data sources for the case study research design, which will be explained in detail in the next two chapters.

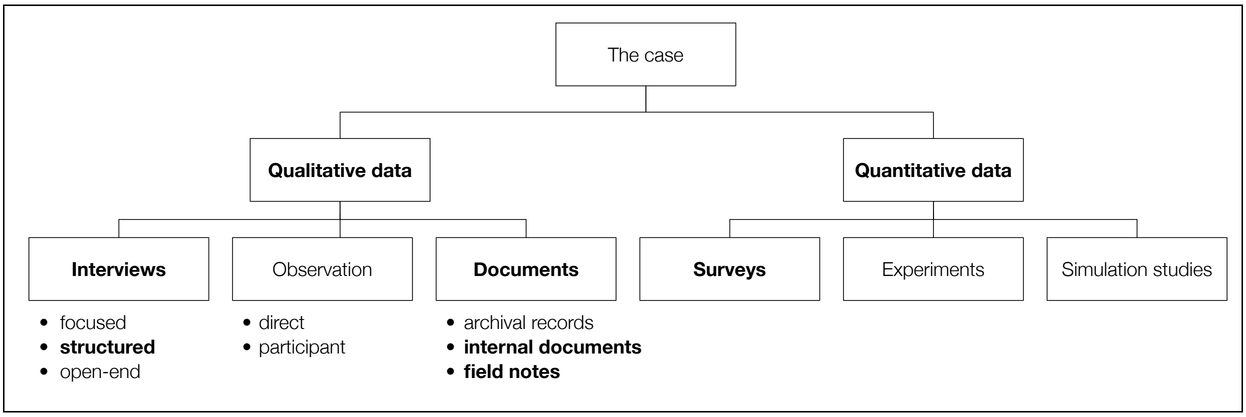


Figure 25: Selected Data Sources within Case Study Design

Notes:
Source: Scholz & Tetje, 2002, p. 14

Study 1: Qualitative study

In order to unveil the role of perceived contextual factors on intended applications for innovation fields, qualitative data was collected from qualitative expert interviews. Qualitative expert interviews can be either (1) explorative, (2) systematized or (3) theory-generating. While explorative interviews gather information for orientation purposes, the systematized interviews are used to obtain unique information from the expert. On the other hand, theory-generating interviews with experts use the expert to overcome subjectivity and try to use the interview as a starting point for formulating theories (Bogner & Menz, 2009, p. 46ff.). The qualitative approach is chosen because there is little empirical research on innovation fields and their contextual factors. Qualitative research is recommended for these circumstances (Griffiths-Hemans, 2006, p. 28; Salomo et al., 2008, p. 569). The expert interviews in this specific context will be a combination of explorative and systematized interviews, thus trying to gain orientation regarding the way in which innovation is managed and obtaining information on specific practices for which only the informant can account, such as the use of innovation fields and contextual factors (Griffiths-Hemans, 2006, p. 28). Using a semi-structured guideline for the interviews secures the systematized way of gathering the information needed, while the explorative character of the interviews offers sufficient freedom to diverge from the guideline. The interviews will be held with innovation management experts from each department of the research subject, the corporate R&D division of a large corporation (n = 22). To select the right participants for the interview, the definition of an expert has to be determined. An expert is a person who owns distinctive knowledge regarding a specific phenomenon, and the expert interview is a means to aspire data about such a phenomenon (Gläser & Laudel, 2009, p. 117). However, experts do not necessarily need to be the renowned leading personalities, rather they can be professionals trained for a particular area of knowledge used in their job position and can be found at all hierarchy levels (Bogner & Menz, 2009, p. 49f.).

The choice of the interviewed persons is based on *purposeful selection*: “This is a strategy in which particular settings, persons, or activities are selected deliberately in order to provide information that cannot be gotten as well from other choices” (Maxwell, 2005, p. 88). The chosen experts are so called innovation management ambassadors, and they are disseminators for the administrative support of the innovation process within their respective departments. They establish a connection between top-down directions and bottom-up feedback regarding the innovation process and know its strengths and weaknesses. This knowledge makes them valid evaluators of the new process step of innovation fields. The interviews are held at the time of the rollout of innovation fields. The objective of the qualitative interviews is to establish a framework for intended applications and their influencing contextual factors.

Further secondary information has been gathered throughout the process of implementation of innovation. This comprises field notes after informal conversations, meeting protocols after department meetings, internal documents such as department descriptions and strategy documents as well as information regarding innovation activities generated by the innovation online information system.

Study 2: Quantitative Data

The findings from the qualitative research will be expanded by conducting a survey with German-based employees of the corporate R&D division (N=1,300) approximately twelve months after the qualitative study. The selection of participants is based on the fact that most of the personnel is located in Germany. Since the survey is conducted twelve months after the qualitative study, the qualitative findings can be corroborated with a larger participant base. Thus, a deeper understanding of the topic can be derived, and the findings can be generalized. This mixed-method approach enables longitudinal data. Keupp, Palmie and Gassmann (2013) support the approach of longitudinal data, since there are only a few studies available with longitudinal data within innovation management: “We therefore believe that future innovation research should seek to retest extant theoretical relationships between internal organisation and innovation using longitudinal datasets and methods” (Keupp et al., 2013). The qualitative and the quantitative data will be triangulated, to countervail validity threats and to bring together complementary information:

> “The original use of' 'triangulation' within the literature of social science methodology, referred to checking the validity of an interpretation based on a single source of data by recourse to at least one further source that is of a strategically different type [...]. Thus, postal questionnaire data may be used to check conclusions reached by semi-structured or unstructured interviews, or vice versa; while interpretations of interview data, produced in varying ways, might be checked through participant observation, or vice versa; and so on. The idea behind this first concept of triangulation is that by drawing data from source that have very different potential threats to validity it is possible to reduce the chances of reaching false conclusions.” (Hammersley, 2008, p. 23)

Thus, the empirical studies will be like parts of a puzzle that generate a holistic picture of intended innovation field applications and the role of contextual factors, if assembled in the right way (Hammersley, 2008, p. 27). Figure 26 shows a flowchart, illustrating the applied research design in the underlying thesis.

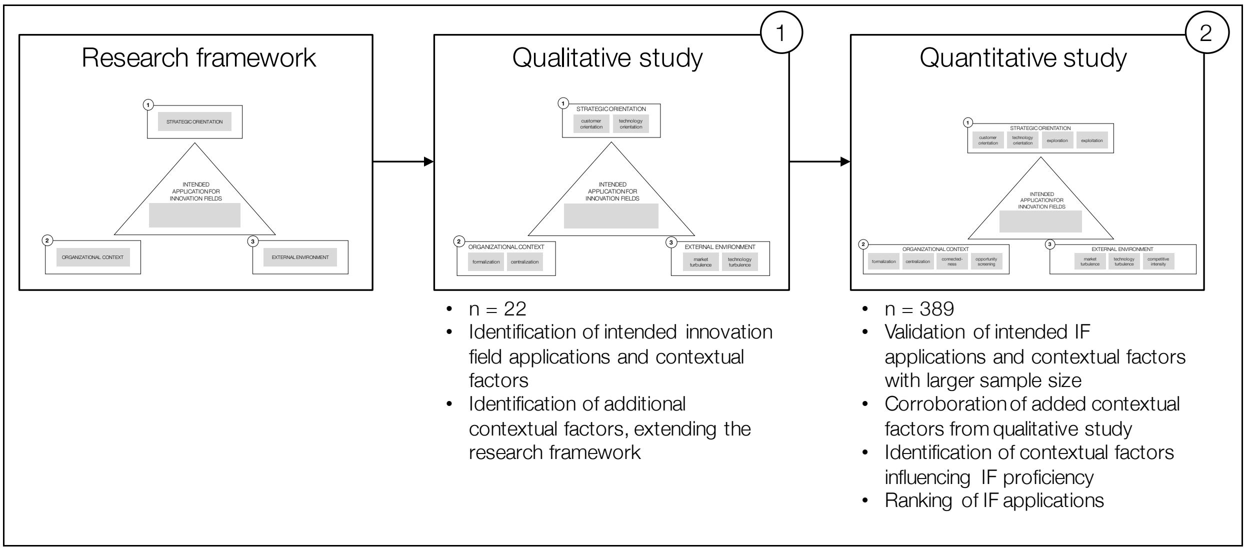


Figure 26: Flowchart of Applied Research Design

Notes:
Source: own representation

Conclusion

- Qualitative research uses non-numerical data to assess the meaning, context, and background of a phenomenon or event. It primarily answers how and why questions.
- Quantitative research uses numerical data to unveil cause-effect relationships.
- While qualitative research enables a deep and rich understanding, quantitative research can generate generalizable findings and validate pre-determined hypotheses.
- While both research types have their advantages and disadvantages, mixed-methods research gains increasing attention, applying both research types and cancelling out the weaknesses of the other.
- Case study research analyzes the phenomenon in its natural context and allows the composition of a comprehensive picture and extensive insights. It is used for how and why questions and for explorative research designs that require a detailed characterization.
- For the underlying research questions, an embedded single case study design with a mixed-methods approach is chosen. The mixed-methods approach is an exploratory sequential mixed-methods design.
- The selected single case is an R&D division of a company located in Germany. This case is well suited since innovation fields had been implemented at the time of the research.

4 Study 1: Qualitative Study

STRUCTURE OF CHAPTER 4: STUDY 1: QUALITATIVE STUDY

4.1 Data Collection
4.2 Framework for Qualitative Study
  4.2.1 Strategic Orientation
  4.2.2 Organizational Context
  4.2.3 External Environment
  4.2.4 Operationalization of Contextual Factors
4.3 Data Analysis
4.4 Results of Qualitative Study
  4.4.1 Primary Intended Applications of Innovation Fields
    4.4.1.1 Intended Application of Innovation Fields for Strategic Purposes
    4.4.1.2 Intended Application of Innovation Fields for Technology Intelligence
    4.4.1.3 Intended Application of Innovation Fields for Lifting Synergies
    4.4.1.4 No Intention to Use Innovation Fields
  4.4.2 Secondary Intended Applications of Innovation Fields
4.5 General Conclusions of Qualitative Results

Figure 27: Chapter Overview of Qualitative Study

Notes:
Source: own representation

The following chapter outlines the conduction and presents the findings of the qualitative study. First, the data collection and analysis are introduced, followed by the presentation of the analytical framework to examine the intended applications of innovation fields. In Chapter 4.4, the findings of the qualitative study are presented and discussed. Finally, general conclusions are drawn from the qualitative study that influence the conduction of the quantitative study.

4.1 Data Collection

As briefly outlined in Chapter 3.4.3, qualitative expert interviews were conducted to answer the research questions on the role of perceived contextual factors on the intended applications of innovation fields.

Twenty-two explorative expert interviews were conducted between April to July 2013. Experts were chosen through *purposeful selection* (Maxwell, 2005, p. 88). The experts had to fulfill the following criteria:

- Affiliation with the corporate R&D division
- Distinctive knowledge and understanding of the innovation process
- Ability to reflect on advantages and disadvantages of the innovation process
- Insights into the general department climate

All of the criteria matched with so-called *innovation management ambassadors*[15] *(IMAs)*. Besides their daily job as a researcher, they hold a special function in their department. They are disseminators of information

[15] Name of this corporate role was adapted due to confidentiality reasons

concerning innovation management, and they provide administrative support for formal and process requirements of innovation activities. They represent the connection between top-down directions regarding changes of the NPD process and bottom-up feedback concerning its strengths and weaknesses. They might be best described as counselors for innovation management related topics. Thus, they are also knowledgeable about the recently-introduced innovation fields and can reflect well on the application, implementation, and feedback towards these fields. According to Bogner and Menz (2009), they count as experts, since they possess a specific area of knowledge in their current position (Bogner & Menz, 2009, p. 49f). To ensure attaining a holistic picture of the implementation of innovation fields at the corporate R&D division, one interviewee per department was selected (n = 22). Twenty interview partners were IMAs, while five additionally held leadership positions. In two departments, no IMA was installed, and thus interviewees were cautiously chosen, matching the above-mentioned criteria. An overview of the interviewees can be found in Table 14.

A study by Griffin & Hauser (1993) shows that twenty interview partners is a sufficient number to obtain 90-95% of the insights (A. Griffin & Hauser, 1993, p. 12; Zahay et al., 2004, p. 660), making 22 interviews a satisfactory sample size to obtain all relevant information.

The interviews were conducted shortly after the implementation of innovation fields in a three-month span, lasting approximately sixty minutes. A semi-structured guideline was used, ensuring sufficient guidance for the structured information collection while leaving sufficient freedom to diverge from the guideline to gain deeper insights into specific aspects. The guideline can be found in Appendix A01.

The interviews focused on the intended applications for innovation fields, due to the short amount of time that has passed between the implementation of innovation fields and the conduction of the interviews. Thus, questions regarding the perceived proficiency have not been asked.

Nineteen interviews were recorded, while for the remaining three extensive notes were taken. The notes and the transcription of the audio file recordings resulted in 220 pages of transcribed material (Appendix A03). The transcribed data was edited and analyzed with the help of Excel and the software program MaxQDA, which supports structuring, evaluating, and preparing the data for interpretation. It stores codes and facilitates the comparison of interview data (Creswell, 2013, p. 203). Computer programs support the analysis process by organizing the data more easily, make it searchable and allowing for more detailed analyses since text can be scanned and coded line by line (Creswell, 2013, p. 201). Furthermore, these programs enable the easy comparison of labels and categories and the creation of a common template (Creswell, 2013, p. 206; Maxwell, 2013, p. 116).

4.2 Framework for Qualitative Study

As introduced in Chapter 2.1.4, the framework used for this explorative qualitative study comprises three main areas: the strategic orientation, organizational context, and external environment. Although this study is of explorative nature, some potential influencing factors will be defined up-front.

Building up on the theoretical work of Montoya-Weiss and Calantone (1994) – who conducted a comprehensive meta-study on antecedents for product development success – the most relevant contextual factors are derived. Montoya-Weiss and Calantone (1994) reviewed about 50 scientific papers and found eighteen determinants in four categories, namely *strategic factors, development process factors, market environment factors and organizational factors* (Montoya-Weiss & Calantone, 1994, p. 403). Table 12 shows the categories and determinants.

Category	Determinants	Description
Strategic factors	Product advantage	Perception of value by the customer
	Technological synergy	Fit between project needs and company skills
	Company resources	Fit between budget and project requirements
	Strategy	**Strategic orientation**
	Marketing synergy	Fit between project needs and company skills
Development process factors	Proficiency of technical activities	Level of maturity of technical activities in NPD
	Proficiency of marketing activities	Level of maturity of marketing activities in NPD
	Protocol	Level of maturity of general NPD aspects
	Top management support/skill	Top management commitment in NPD
	Proficiency of pre-development activities	Level of maturity of front-end of innovation activities
	Speed to market	Speed of NPD
	Financial / business analysis	Level of maturity of business analysis
	Costs	Level of NPD costs
Market environment factors	Market potential	Market size and growth
	Market competitiveness	Competitive intensity
	Environment	**Level of risk, uncertainty, turbulence**
Organizational factors	Internal/external relations	Coordination of activities in and outside the company
	Organizational factors	**Organizational structure and climate**

Table 12: Overview of Main Determinants of NPD success

Notes:
Source: Montoya-Weiss & Calantone, 1994, p. 406ff.

The categories strategic factors, market environment factors and organizational factors are in line with more recent literature such as Tidd (2011), Tidd and Bessant (2013) and Trott (2008), which distinguish between the main categories of strategic orientation, organizational context and external environment (Tidd, 2001, p. 174; Tidd & Bessant, 2001, p. 313; Trott, 2008, p. 81). Since innovation fields are part of the innovation process located in the front-end of innovation, certain factors describing the specific development process are less relevant and thus will be omitted in the study. Furthermore, some determinants are more relevant than others in the context of the research objective and research setting. Thus, in the following, the factors for the underlying qualitative study will be presented, explained, and selected for the R&D context in which this study takes place.

4.2.1 Strategic Orientation

Strategic orientation evolves around the long-term orientation of the business regarding innovation and the interdependence to the corporate strategy and objectives (De Massis et al., 2013, p. 11; Tidd &

Bessant, 2001, p. 169). It guides the attitude and behavior of employees and helps to determine the search boundaries and scope (Charles H Noble, Sinha, & Kumar, 2002, p. 26; Spanjol, Rosa, & Qualls, 2011, p. 237), which is a critical success factor for innovation. Several papers report an influence of strategic orientation on NPD performance (Gatignon & Xuereb, 1997; Li & Atuahene-Gima, 2001; Zahra & Covin, 1993). Other scholars show a relation between specified strategic objectives and enhanced creativity and ideation (Amabile, 1998; Spanjol et al., 2011).

Montoya-Weiss and Calantone (1994) argue that in the strategic context, product advantage, company resources, technological and marketing synergy and strategy are relevant factors for NPD success (Montoya-Weiss & Calantone, 1994). For the underlying research setting, only the factor of *strategy* will be selected as a contextual factor. The determinants regarding synergy are not needed, since one of the applications described by literature is the application of innovation fields for synergies, making it rather a dependent factor than an independent influencing factor. Moreover, the factors of product advantage and company resources play a secondary role in the R&D context, since the outcomes of innovation activities that are carried out might not reflect the ultimate and sole product advantage for the launched product and company resources are determined on a yearly basis as a fixed budget.

The factor of strategy comprises strategic orientation and is described by Gatignon and Xuereb (1997) as “the strategic directions implemented by a firm to create the proper behaviors for the continuous superior performance of the business” (Gatignon & Xuereb, 1997, p. 78). The strategic orientation has three distinct directions: customer (market) orientation, technology orientation, and competitor orientation. The strategic orientation examines whether the strategy is aligned according to customer needs, competition, or technological changes and thus which of these characteristics is in focus. Additionally, the strategic orientation can be motivated externally or internally. External motivation is assigned to customer orientation, while internal motivation is linked to technology orientation (Spanjol et al., 2011, p. 237). Competitor orientation will be omitted since it is assumed that the orientation towards direct competitors (other research institutes or corporate R&D divisions from other companies) is a factor of minor relevance.

Customer orientation is described as “[…] a firm with the ability and the will to identify, analyze, understand, and answer user needs” (Gatignon & Xuereb, 1997, p. 78). The voice of customer holds special relevance for customer-oriented companies and resources are allocated according to customer needs, as well as to grant customer satisfaction and greater value for them (Auh & Menguc, 2007, p. 1024; Deshpandé, Farley, & Webster, 1993, p. 27; Narver & Slater, 1990, p. 21; Charles H Noble et al., 2002, p. 27). Empirical evidence points towards customer orientation as enhancing firm performance (Auh & Menguc, 2007, p. 1024; Jaworski & Kohli, 1993, p. 63; Narver & Slater, 1990, p. 27). The behavior leading towards customer orientation is described as following procedures and routines such as the integration and generation of customer information by observing and evaluating needs while at the same time sharing this information within the organization, ultimately leading to a change in strategy (Auh & Menguc, 2007, p. 1024; K. Eisenhardt & Martin, 2000, p. 1108; Narver & Slater, 1990, p. 22).

Technological orientation is "[…] a firm with the ability and will to acquire a substantial technological background and use it in the development of new products" (Gatignon & Xuereb, 1997, p. 78). This orientation emphasizes the acquisition or exploration of new and state-of-the-art technologies and the use of high-level technologies during development. Furthermore, this orientation indicates that the company has strong capabilities to utilize existing technological knowledge to develop new solutions, ultimately responding to the needs of customers (Gatignon & Xuereb, 1997, p. 78; Zheng, Yim, & Tse, 2005, p. 45). These companies are perceived as more proactive and thus "less likely to restrict their innovation efforts to already existing product categories and encourages novel ideas to be generated and considered for development" (Spanjol et al., 2011, p. 239). For those companies, creativity and ideation are corporate standards, steering the company's strategy and activities, while out-of-the-box ideas are encouraged (Zheng et al., 2005, p. 46). Several studies show a positive impact of technology orientation on the novelty of new product ideas (Spanjol et al., 2011, p. 243), the uniqueness of ideas and greater product advantage (Gatignon & Xuereb, 1997, p. 87) as well as radical innovation (Zheng et al., 2005, p. 50).

Both orientations will be incorporated into the framework, knowing, that these might not be the only factors influencing innovation field application.

4.2.2 Organizational Context

Organizational context refers to the "recurring patterns of behavior, attitude and feelings that permeate work in the innovation process" (De Massis et al., 2013, p. 12; Tidd, 2001, p. 178; Tidd & Bessant, 2001, p. 107; Trott, 2008, p. 91f.). Gibson and Birkinshaw (2004) describe them as stimulants coming from the organization or factors emerging from the environment that affect beliefs and mindsets (Gibson & Birkinshaw, 2004, p. 213).

In the meta-study of Montoya-Weiss and Calantone (1994), the elaboration of critical organizational success factors remains vague. They only refer to internal/external relations and organizational factors. For the qualitative study in place, organizational factors will be highlighted, while internal/external relations such as the coordination of activities within a company will be omitted since it is assumed that they play a secondary role in this context.

Two main factors are discussed diversely in the context of innovation, namely centralization and formalization. Both are discussed ambiguously regarding their influence on innovation as an inhibitor or enabler (Damanpour, 1991; Schultz, Salomo, de Brentani, & Kleinschmidt, 2013). Thus, for the underlying study, centralization and formalization will be proposed as influencing factors of innovation field application.

Centralization refers to the way in which decisions are made and where they are concentrated within an organization (Aiken & Hage, 1968, p. 928; Damanpour, 1991, p. 589). It is also referred to as the inversion of the delegation of decisions made or the degree of influence on decisions by employees (Auh & Menguc, 2007, p. 1025; Jaworski & Kohli, 1993, p. 56). Centralization is an important factor for information diffusion, which is especially relevant in the front-end of innovation since high centralization delays or even obstructs the spread of information within the organization (Auh & Menguc, 2007, p. 1025). Studies have shown that centralization reduces the innovation performance regarding the “quality and quantity of ideas” (Jansen et al., 2006, p. 1663; Sheremata, 2000, p. 396).

As highlighted in Chapter 2.3.3.5, the degree of **formalization** is a highly debated topic in the front-end of innovation. Formalization is described as a behavior control mechanism indicating the level of rules, determining processes, standards, procedures, information exchange and decisions (Jaworski & Kohli, 1993, p. 56). It specifically defines the importance of adhering to rules and procedures and documentation, forcing employees not to align according to the company’s determined standards (Auh & Menguc, 2007, p. 1025; John & Martin, 1984, p. 172). Formalization has the ability to frame the implementation of innovation activities through defined processes (Damanpour, 1991; Schultz et al., 2013), as well as the search scope and boundaries for innovation (Rosenkopf & Nerkar, 2001; Spanjol et al., 2011).

Formalization is hypothesized as affecting the way in which information is processed (Auh & Menguc, 2007, p. 1025). Information processing holds particular importance in the front-end of innovation (Gordon, Tarafdar, Cook Robert Maksimoski, & Rogowitz, 2008, p. 52; Markham, 2013, p. 79; Nyffenegger, Jamali, Kobe, & Meier, 2005, p. 1). On the one hand, formalization reduces flexibility and increases bureaucracy, while at the same time it can cope with rising complexity and ensure common understanding, helping to cut time and cost (Adler & Borys, 1996, p. 63; Kleinschmidt et al., 2007, p. 431; Tatikonda & Rosenthal, 2000, p. 405). Especially in turbulent surroundings, formalization has a negative impact, impeding the necessary leeway, especially in the front-end of innovation (Poskela & Martinsuo, 2009, p. 676). On the other hand, formalization supports the effective and efficient management of front-end activities (J. Kim & Wilemon, 2002a, p. 274).

Due to the ambiguous findings about centralization and formalization and the role that they play regarding innovation, these factors need to be examined to ascertain how they influence the intended application of innovation fields.

4.2.3 External Environment

External environment contains the external complexity, uncertainty, and turbulence towards, e.g. the market, technology and competitors (Tidd, 2001, p. 175).

The external environment is best described through market and technological turbulence. **Technology turbulence** is described as “the rate of technological advances within an industry” (Zhou et al. 2005, S. 47). On the other hand, **market turbulence** is defined as “the rate of change in the composition of customers and their preferences” (Jaworski & Kohli, 1993, p.57). Along the lines of Santos-Vijande and Alvarez-Gonzales (2007), market turbulence also captures market uncertainty, described by the ability to “predict […] accurately the future of the market preferences” (Santos-Vijande & Álvarez-González, 2007, p. 519). Unlike the aforementioned customer orientation, market turbulence grasps the turbulence of the external market and external customers. The external environment is described as an influential context factor regarding innovation performance and innovativeness, thereby posing an important factor for the intended application of innovation fields (Gatignon & Xuereb, 1997; Santos-Vijande & Álvarez-González, 2007; Zheng et al., 2005).

The meta-study by Montoya and Calantone (1994) describes the factors of market potential, competitiveness, and environment as influential factors. Competitiveness comprises the intensity of competition in the market, while environment captures the risk, uncertainty, and turbulence regarding market and technology. Market potential is defined as market size and growth (Montoya-Weiss & Calantone, 1994, p. 415). Market potential is excluded since this factor holds secondary relevance in the front-end of innovation, even more so in the context of R&D activities. Furthermore, competitiveness will be excluded, because it is assumed that it holds minor importance for the underlying R&D setting.

The factor of the external environment is captured with the concept of turbulence. A differentiation is made between market and technology turbulence because there might be different implications and consequences depending on the type of turbulence (Atuahene-Gima, Li, & De Luca, 2006; Danneels & Sethi, 2011; Tsai & Yang, 2013). It is assumed that for the context of R&D, turbulence holds greater importance than, e.g. competitive intensity regarding the influence on innovation activities. Candi et al. (2013) show a positive effect between technological turbulence and strategic flexibility regarding NPD (Candi, Van Den Ende, & Gemser, 2013, p. 138), while Tsai and Yang (2013) show a moderating effect of market turbulence on innovativeness and business performance (Tsai & Yang, 2013, p. 1287).

The following framework (Figure 28) will accompany the analysis of the qualitative study, aggregating all prior-described contextual factors. The center of the framework captures the intended application of innovation fields discovered in the interviews, while the three corners of the triangle depict the three main contextual themes and their according factors. For the conduction of this study, only the intended applications for innovation fields were examined, due to the limited timeframe between the implementation of innovation fields and conduction of the interviews.

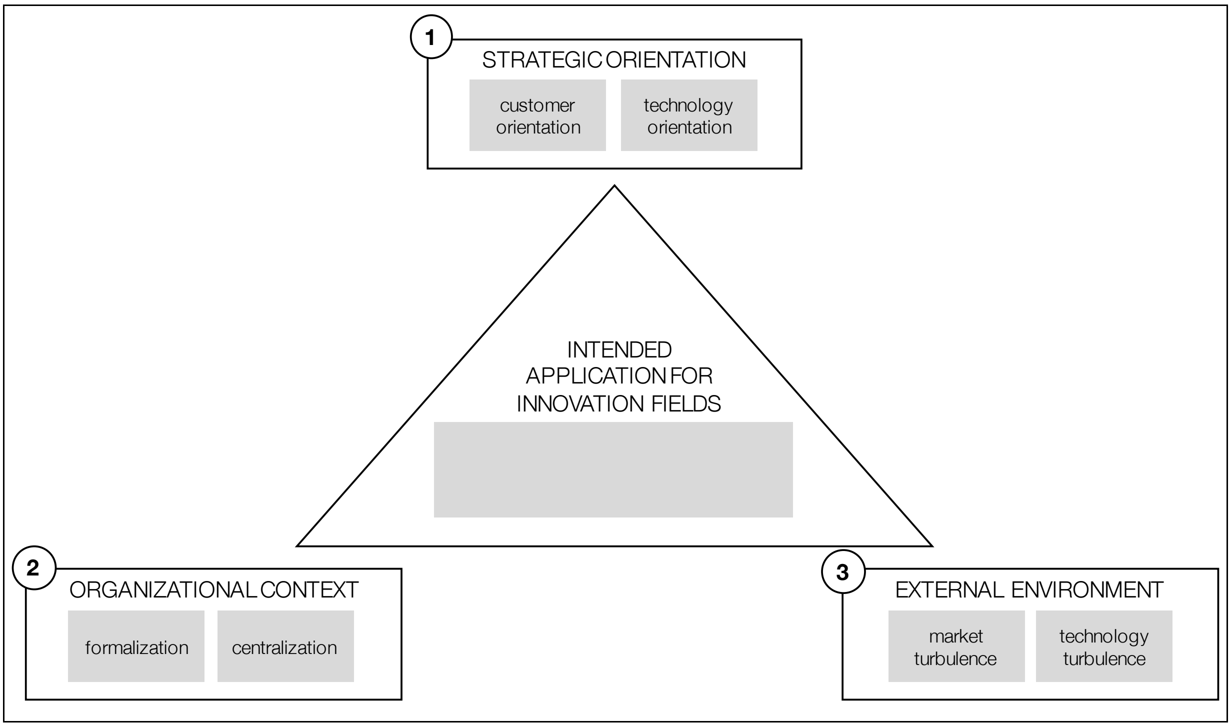


Figure 28: Qualitative Research Framework to Study Intended Application of Innovation Fields

Notes:
Source: own representation

4.2.4 Operationalization of Contextual Factors

The contextual factors were operationalized through specific questions in the interview. The strategic orientation was derived from the described proximity to the customer, such as the strength of the relationship to the customer as well as the degree to which input regarding search scope was delivered. Formalization was captured through the search boundaries in the front-end of innovation as well as overall process formalization. Centralization was best described through statements regarding the way in which innovation fields were generated (top-down or bottom-up) and the overall decision autonomy of the innovation management ambassadors derived by the respective tasks, such as budget responsibility. The contextual factors regarding the external environment were derived through a self-assessment after the interview in addition to an expert check by two department heads (innovation manager and assistant to the CEO) of the corporate R&D division. Both experts possess an extensive knowledge and overview about tasks and turbulence of the respective research units. All contextual factors were categorized as low or high for each interview, in addition to the collection of citations supporting the categorization.

	Contextual factor	**Operationalization**
Strategic orientation	Customer orientation	Proximity to internal customer • Strength of relation of research unit to internal customer • Degree of input by internal customer
	Technology orientation	
Organizational context	Formalization	• Freedom of search scope in the front-end of innovation • Overall process formalization
	Centralization	• Autonomy of innovation field deduction (top-down / bottom-up) • Overall decision autonomy of innovation management ambassador
External environment	Market turbulence	Self-assessment of market turbulence + expert check
	Technology turbulence	Self-assessment of technology turbulence + expert check

Table 13: Operationalization of Contextual Factors

Notes:
Source: own representation

4.3 Data Analysis

Qualitative data analysis comprises several tasks: the (1) preparation of data, (2) data reduction, (3) data condensation and (4) display of data (Creswell, 2013, p. 180; Maxwell, 2013, p. 105). This is all undertaken in the so-called “data analysis spiral”, containing (1) the management of data, e.g. the transfer of spoken words into transcripts, (2) reading and first-coding the data into broad themes, (3) describing, explaining and categorizing the data and (4) illustrating the results and interpretations (Creswell, 2013, p. 183). Figure 29 shows this spiral.

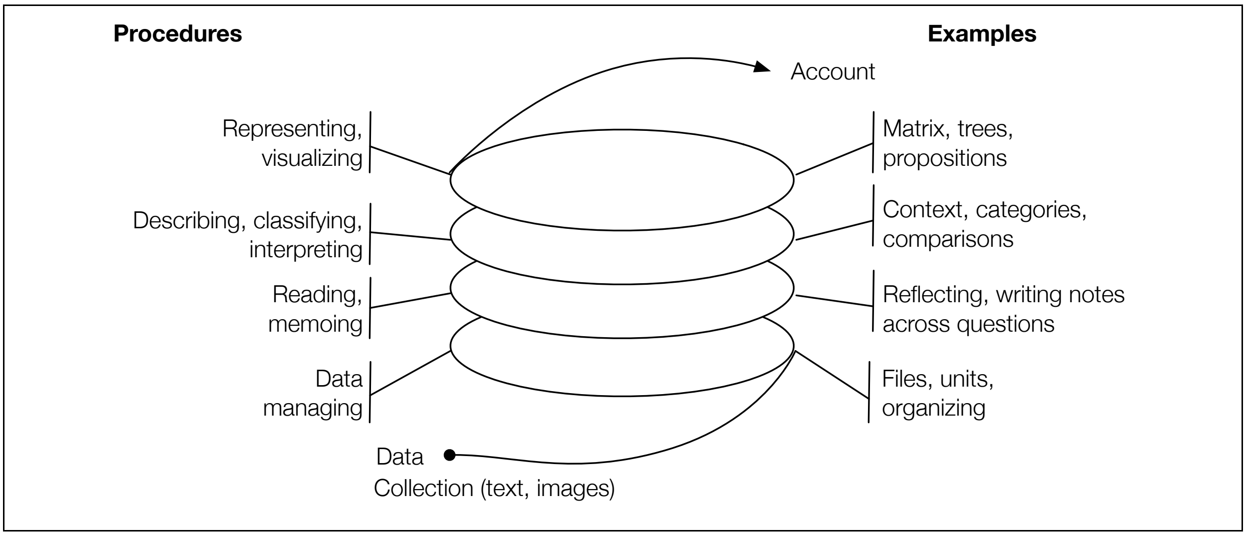


Figure 29: Data Analysis Spiral for Qualitative Data Analysis

Notes:
Source: Creswell, 2013, p. 183

Reading and first-coding the data are the initial steps to explore the available data and make sense of the information at hand. The second step is the core of the qualitative data analysis: “Here researchers build detailed descriptions, develop themes or dimensions, and provide an interpretation in light of their own views or views and perspectives in the literature” (Creswell, 2013, p. 184). During this step, codes are built, meaning that text is aggregated and put into defined categories of different size and scope. With codes, the data is split up and rearranged differently to grasp insights and to detect returning patterns (Maxwell, 2013, p. 107; M. B. Miles & Huberman, 1994, p. 73). This also means that not all data is used and some of it will be dismissed. There are several ways to create the codes. They can either be created while reading through the text – so-called *open coding* – or they can be *pre-figured,* meaning that they are created beforehand (Creswell, 2013, p. 185). Irrespective of the way in which the codes are established, it is important to note, that coding is an iterative process, where refinement of the codes or re-labeling of codes is part of the analysis (M. B. Miles & Huberman, 1994, p. 82). Maxwell (2013) distinguishes between substantive and theoretical codes: substantive codes are of a describing substance, developed through open coding, while theoretical categories "place the coded data into a more general or abstract framework" and are often pre-figured (Maxwell, 2013, p. 108). Once the codes are established, the findings obtained need to be described, and the results need to be interpreted (Creswell, 2013, p. 187).

As Creswell (2013) states, the analysis procedure is custom to each study, and there is a vast number of different techniques to achieve this (Creswell, 2013, p. 182). The choice between different analytical strategies needs to be made in accordance with the research question. The goal of the underlying qualitative study is the discovery of applications and contextual factors for innovation fields. For this purpose, three aspects hold relevance: (1) the discovery of common themes for intended innovation field application, (2) the relationship of categories towards these themes and (3) comparing and contrasting the results of different cases. Maxwell (2013) calls analytics based on similarity and comparison, a *categorizing strategy* (Maxwell, 2013, p. 115), while Yin (2013) calls this step *cross-case synthesis* (Yin, 2014, p. 164).

For the underlying thesis, the transcripts were read through several times in order to gain a sense of the information available and a feeling for the data. Furthermore, notes were taken when interesting details or contrasting pictures emerged. This reflection helped to create initial themes to split up the text for further analysis. These themes mainly work as sorting buckets for the next analytical steps, although they do not add substantial value or offer additional insights (Maxwell, 2013, p. 107).

Following this, with the help of the established framework, the pre-defined categories were assigned to the text. This means that certain aspects in the text lines got a label assigned to them. This procedure was conducted with all of the interviews. The type of labels varied between substantial (descriptive) and theoretical (framework) codes. During this approach, categories were refined, discarded, or combined, going back and forth between the text and the definition of the categories. With the established categories in mind, the text was reread to ensure that all relevant text passages for the categories were captured.

Subsequently, each category was analyzed with a cross-case synthesis, using word tables incorporating "the data from the individual cases according to one or more uniform categories" (Yin, 2014, p. 165). An extensive word table was established to compare and analyze the data. This serves several purposes: similarities and differences can be shown, applications can be unveiled, and general conclusions can be drawn from the data (see Appendix A04 for data table) (Creswell, 2013, p. 199; Maxwell, 2013, p. 108; M. B. Miles & Huberman, 1994, p. 91; Yin, 2014, p. 167). The array additionally serves to unveil application *profiles*, showing similar applications and corresponding contextual factors. Thus, contrasting profiles have been uncovered (Yin, 2014, p. 167). Furthermore, the best strategy to display data in a cross-case analysis is to display it in a visual framework (M. B. Miles & Huberman, 1994, p. 102). With this kind of analysis, generalizability can be enhanced, showing that the application behavior is rather recurring rather than unique and specified for one single embedded case (M. B. Miles & Huberman, 1994, p. 100). Using several embedded cases strengthens the results and offers deeper insights into the "conditions under which a finding will occur", as well as preparing for tying in larger case numbers (M. B. Miles & Huberman, 1994, p. 101). In this case, the general results, in turn, can be used to be applied to a larger sample size such as a follow-up quantitative study (Creswell, 2013, p. 199). It is important to note that in a cross-case synthesis, the conclusions are not drawn by numeric counts, but rather are carried by *argumentative interpretation* (Yin, 2014, p. 167).

4.4 Results of Qualitative Study

This section presents the findings of the qualitative study. The section describes the discovered types of applications for innovation fields and secondly the contextual factors influencing those applications. The developed framework from Chapter 4.2 is used to classify the intended innovation field applications and their contextual factors. Table 14 presents a summarized view on interview data and framework characteristics. The table describes the role and affiliation of the interview partner within the corporate R&D division and the number of employees in the department. Furthermore, it shows the general intention to use innovation fields and the primary and secondary applications for innovation fields. Primary applications comprise the description of the main intended application, while secondary applications have only been mentioned during the interview as a potential future application. Finally, the three different contextual factors of (1) strategic orientation, (2) organizational context and (3) external environment and their specification are shown. The table is sorted according to the primary intended application[16] of innovation fields. Sorting by the primary intended application of innovation fields revealed specific and uniform patterns of the contextual factors, which will be discussed in the following.

Four different primary applications emerged from the analysis. These comprise intended application for strategic purposes, technology intelligence, lifting synergies and non-usage of innovation fields. Ideation and portfolio extension were revealed as secondary intended applications.

In the following, the intended applications will be described, followed by an explanation and discussion of the perceived contextual factors. Finally, general conclusions from the qualitative study to be considered for the quantitative study are drawn in Chapter 4.5.

[16] Sorting the table by unit also revealed interesting results. For the purpose of this study, the discovery of applications and contextual factors are the paramount objective. The table sorted by unit can be found in Appendix A02.

No.	Unit	Interviewee	No. of employees	Intention to use and applications for innovation fields			Strategic orientation		Organizational context		External environment	
				General intention to use	Primary intended application	Secondary intended application	Customer orientation	Technology orientation	Centralization	Formalization	Market turbulence	Technology turbulence
7	Unit 4: Materials & Sensors	IMA	69	high	Strategic purposes		high	low	low	high	low	high
4	Unit 5: Components	IMA	72	high	Strategic purposes	Ideation	low	high	high	high	low	low
8	Unit 5: Components	IMA	45	high	Strategic purposes		low	high	low	high	low	high
14	Unit 6: Manufacturing Technologies	Executive & IMA	83	high	Strategic purposes	Portfolio extension	high	low	high	high	low	high
6	Unit 4: Materials & Sensors	Executive & IMA	24	high	Technology intelligence	Strategic purposes	high	low	low	high	low	low
11	Unit 6: Manufacturing Technologies	IMA	101	high	Technology intelligence	Strategic purposes	high	low	low	low	low	low
13	Unit 6: Manufacturing Technologies	IMA	42	high	Technology intelligence	Strategic purposes	high	low	low	high	low	high
19	Unit 2: Software Systems	Executive & IMA	69	high	Lifting synergies	Strategic purposes	low	high	high	high	low	high
9	Unit 2: Software Systems	Executive & IMA	82	high	Lifting synergies		high	low	low	low	low	high
17	Unit 2: Software Systems	Executive & IMA	59	high	Lifting synergies	Technology intelligence	low	high	low	high	high	high
18	Unit 5: Components	IMA	47	high	Lifting synergies	Ideation	low	high	high	high	low	high
3	Unit 1: Mobility Systems	IMA	74	low	None	Lifting synergies	high	low	high	low	high	high
15	Unit 1: Mobility Systems	IMA	85	low	None	Portfolio extension	high	low	high	high	low	low
20	Unit 1: Mobility Systems	IMA	87	low	None	-	high	low	high	high	low	low
21	Unit 3: Consumer Goods	Research employee	18	low	None	-	high	low	low	low	low	high
1	Unit 3: Consumer Goods	IMA	20	low	None	-	high	low	high	high	low	high
22	Unit 3: Consumer Goods	Executive	41	low	None	-	high	low	high	high	high	high
16	Unit 4: Materials & Sensors	IMA	51	low	None	Lifting synergies	low	high	low	high	high	high
5	Unit 4: Materials & Sensors	IMA	82	low	None	Ideation	high	low	high	high	high	high
12	Unit 4: Materials & Sensors	IMA	81	low	None	Lifting synergies	high	low	high	high	high	high
2	Unit 5: Components	IMA	34	low	None	Strategic purposes	low	high	high	low	low	low
10	Unit 6: Manufacturing Technologies	IMA	65	low	None	Strategic purposes	high	low	high	low	low	high

Table 14: Overview of Qualitative Interview Findings

Notes:
Source: own representation
IMA = Innovation Management Ambassador

4.4.1 Primary Intended Applications of Innovation Fields

The next chapters elaborate on the primary intended applications of innovation fields and their according perceived contextual factors.

4.4.1.1 Intended Application of Innovation Fields for Strategic Purposes

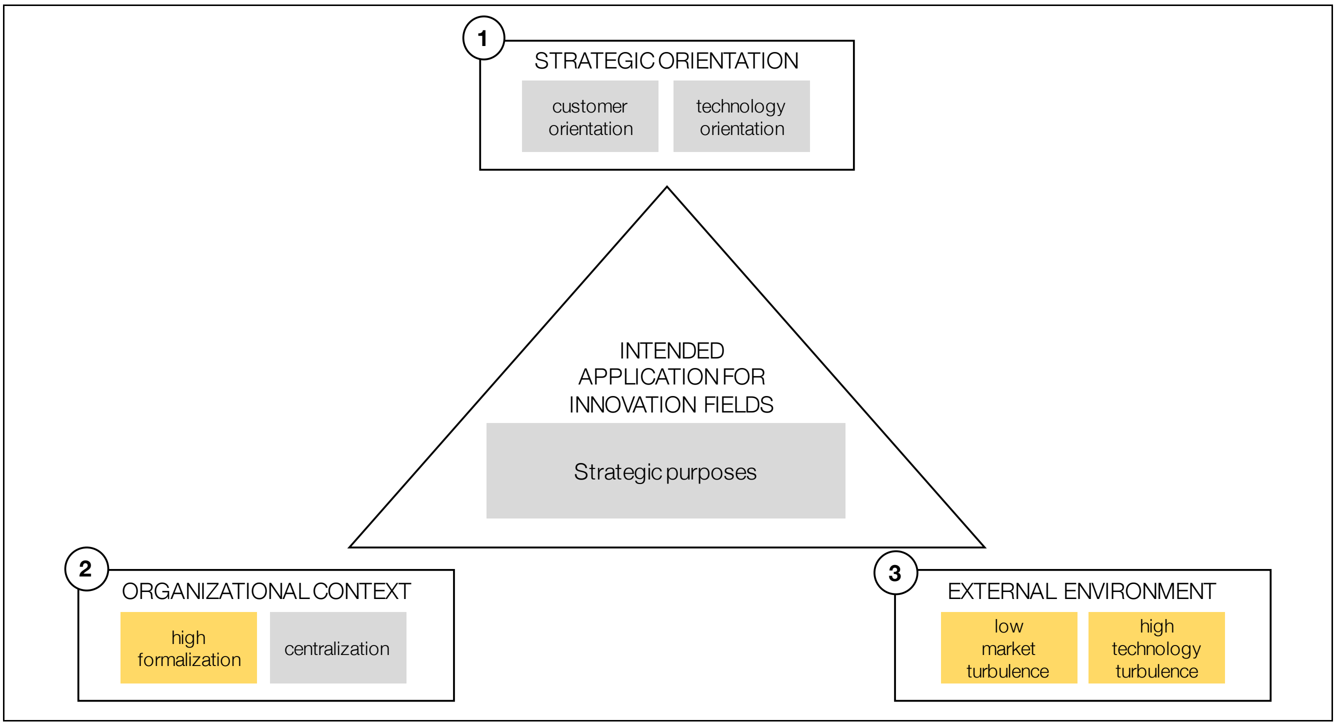


Figure 30: Findings for Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: own representation

Description of Intended Application

Using innovation fields for strategic purposes can have different objectives: (1) portfolio management and an overview of innovation activities (interviewee 4, 7,8) and (2) a focus on dedicated topics (interviewee 14). Using innovation fields for portfolio management is explained by interviewee 8:

> *"Our executive has asked me to update our monthly innovation report. In the new draft, there are innovation fields and the according scouting activities. I cluster the innovation fields to see which studies are being worked on in what fields and which ones are empty. In those [that are empty], innovation activities should be started. That means that I try to do strategic innovation [with this new report.]"* (interviewee 8)

What is implied by *strategic innovation* (interviewee 8) is (1) establishing a link between the corporate strategy and innovation activities and the (2) monitoring and balancing of activities to ensure a more strategic focus for innovation activities. Interviewee 4 describes the application of innovation fields for strategic purposes in tracking the state of the current innovation pipeline and deciding whether to reallocate resources. By using innovation fields, interviewee 7 already discovered a mismatch in the resource allocation: *"I recently used the innovation fields to prepare the strategy meeting of our unit. I prepared a picture, and while working on it, we realized that we do not treat a certain* *topic yet" (interviewee 7).* Interviewee 14 further elaborates how important focus is for his department: *"We need a unique selling point that we need to focus on. I cannot do everything. […] Our five innovation fields that we have defined account for our specific search directions in the next two to three years"* (interviewee 14).

Perceived Contextual Factors

The qualitative results show three influencing factors shaping the intended application of innovation fields for strategic purposes. The respondents shared the notions that (2) formalization is perceived as high, (3) market turbulence is low, and technology turbulence is high in case of the reported intended application of innovation fields for strategic purposes. No clear indication was given for the contextual factor (1) of strategic orientation.

Organizational Context (2)

A formalized environment enforces control of innovation activities, as interviewee 8 describes: *"The innovation management process is not always executed as it is described. Our executives request things at a very early stage, such as prototypes when the process does only ask for a concept description"* (interviewee 8). Furthermore, the respondent describes that prior to gate decisions (e.g. before a practical study), many iterations with the executives are needed. These statements suggest that using innovation fields for strategic purposes in a formalized culture give additional structure to the front-end of innovation. A study by Kock et al. (2015) shows a positive effect of process formalization towards FEI success (Kock et al., 2015, p. 548). Process formalization gives guidance and *collective orientation* for the procedures and process steps and in this case a strategic direction for the department or even the whole R&D division (Tatikonda & Rosenthal, 2000, p. 405). Furthermore, the coordination and effectiveness of activities can be improved since the procedures are universally known and acted upon (Kock et al., 2015, p. 543; Poskela & Martinsuo, 2009, p. 675).

External Environment (3)

High technology turbulence could indicate the need for observation of the technological landscape to avoid missing technological advancements that are crucial to the success of the corporate R&D division. A portfolio management approach with determined technological innovation fields can facilitate a technology overview, which allows seeing all activities at a glance and re-allocating resources if needed. This notion suggests that innovation fields might indeed be used to balance the search strategies of exploration and exploitation in order to achieve sustained success (He & Wong, 2004, p. 484; C. Kim et al., 2012, p. 1193).

Additionally, low market turbulence indicates the need to generate new ideas in new business areas to sustain in the market. This implicates determining of innovation fields beyond the current business scope to ensure the discovery of new opportunities in white spaces (interviewee 7 and 14).

Interestingly, both interviewees 4 and 8 – who work for Unit 5: Components & Simulation – intend to use innovation fields for portfolio management purposes. One indication why this application is fruitful for them is explained by interviewee 4: *"Our problem is that we typically do not create products […] and that we only have internal customers. In the best case, we deliver a piece of a product, but never a product"* (interviewee 4). This could mean that innovation fields can help them to provide more structure and better understanding the bigger picture.

Furthermore, all four departments belong to the so-called *technology research area*. Their focus is the discovery, technical configuration, and implementation of new technologies to existing or new products as opposed to constructing and designing new components and products for the business divisions. For employees of the technology research area, it is often the case that *a solution seeks an appropriate use case* (field note, March 2013). Having an overview of all innovation fields helps them to combine their technologies with potential use cases, indicating that the application of innovation fields for strategic purposes might be more relevant for this research area.

Conclusion

- Applying innovation fields for strategic purposes implies (1) portfolio management and (2) enhancing strategic focus.
- Applying innovation fields for strategic purposes occurs more likely in a formalized environment, with low market and high technological turbulence.
- Applying innovation fields for strategic purposes seems to be more relevant to the technology research area to (1) understand the bigger picture of the research activities and (2) to get an overview of appropriate use cases for technologies.

4.4.1.2 Intended Application of Innovation Fields for Technology Intelligence

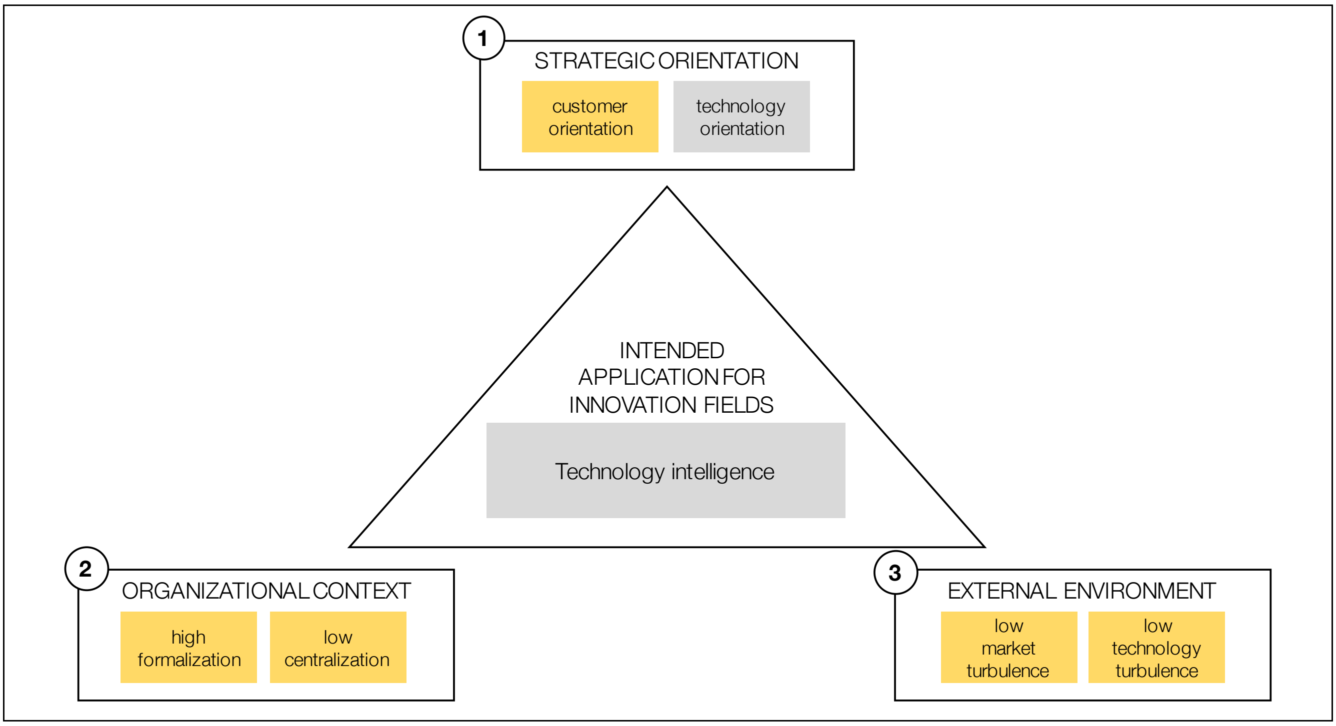


Figure 31: Findings for Intended Application of Innovation Fields for Technology Intelligence

Notes:
Source: own representation

Description of Intended Application

As described in Chapter 2.4.2.4, technology intelligence can be described as the "systematic identification of future chances as well as threats for the company" (Wellensiek et al., 2009, p. 2). This is usually achieved by identifying and interpreting weak signals in the corporate context to gain additional value for upcoming developments. Innovation field application for technology intelligence comprises (1) the storage and linkage of weak signals in innovation fields and (2) it acts as a filter for weak signal assignment and interpretation. *"[Innovation fields] fit very well with the technology intelligence because you can link it [...]. Through technology detection you can uncover trends on a more detailed level, going beyond general tags leading to the creation of detailed ideas"* (interviewee 13). Interviewee 11 even has a process for technology detection: *"Every employee has a corresponding innovation field that he monitors. There, he looks for weak signals."*

Perceived Contextual Factors

The qualitative study revealed the pattern whereby innovation fields are used for technology intelligence when the strategic orientation is customer-oriented, centralization is low, formalization is high, and the market and technology turbulence are indicated as low.

Strategic Orientation (1)

Both interviewees 11 and 13 collaborate intensively with their internal customers. Interviewee 13 describes that they regularly ask for changes in the customer needs, while interviewee 11 states that they even collaborate with the customer at a very early stage. This could mean that departments using innovation fields for technology intelligence can rely on their customers to deliver specific requirements from which to source weak signals. Interviewee 11 draws another conclusion: *"In my perspective, in the technology research area, the front-end of innovation is not possible without a clear strategy. For this, we need a very tight link to our customers"* (interviewee 11). This statement is in line with the notion that all departments using innovation fields for technology intelligence belong to the *technology research area*, drawing a similarity to the intended application of innovation fields for strategic purposes.

Organizational Context (2)

Technology intelligence indicates that employees are invited to participate in the detection of trends and weak signals, explaining the low centralization, which is shown through the decisional autonomy in the front-end of innovation. All respondents were responsible for the allocation and clearance of budget of innovation activities such as the technical and practical studies. Decentralizing decision-making, while giving more responsibility to employees can be interpreted as a higher degree of freedom.

Interviewee 6 states that there are very structured work packages that need to be processed when elaborating on an idea, which accounts for high process formalization, while interviewee 13 describes that the formalization cannot necessarily be ascribed to the process, but rather it is triggered through the management, which demands the measurable benefits of the idea and the concept at an early stage.

There is empirical evidence that low centralization and high formalization constitute a very favorable setting. Low centralization encourages autonomy and involvement while averting a narrowing bureaucratic structure. Sufficient freedom is provided for the discovery of weak signals, while the formalization ensures no loss of control due to the established systematic for the processing of technology intelligence (Auh & Menguc, 2007, p. 1026; Lin & Germain, 2003, p. 1136).

External Environment (3)

Low market and technology turbulence point towards the intended application of innovation fields for technology intelligence for grasping new technologies and trends for future research projects. The low turbulence provides a stable environment, which might call for proactive behavior in the search for new research projects. Especially in the R&D setting, the search for novel technologies is generally beyond the scope of current business (Clark & Fujimoto, 1991, p. 26), implying that the search for new advancements happens regardless of the turbulence level. Two of three respondents belong to Unit 6: Manufacturing Technologies. The strategy document for this unit underlines the low turbulence by revealing that at the time of the qualitative study, Industry 4.0[17] was not yet seen as a major topic, but was monitored closely for possible disruptive potential. Furthermore, a research note indicated that Unit 6: Manufacturing Technologies had made substantial progress in some of its research projects, even winning a renowned inventor award for one of its technologies (field note, October 2013). This indicates that the unit found itself in a situation of competitive advantage, temporarily dominating technological advancements and thus further supporting the perceived low turbulence.

Conclusion

- Using innovation fields for technology intelligence occurs more likely in a formalized and less centralized environment, with low market and technological turbulence and customer orientation.
- Applying innovation fields for technology intelligence is linked to using innovation fields for strategic purposes.
- Using innovation fields for technology intelligence seems to be helpful to departments within the technology research area, especially for the development of manufacturing technologies, mainly discovering and implementing new technologies, thus searching for their potential use cases.

[17] Industry 4.0 is a primarily German-driven development of intelligent production processes and technologies. As a countermovement to mass-production in low-wage countries, industry 4.0 develops highly individualized and flexible production possibilities, establishing smart factories where batch-sizes can be tremendously reduced (Brettel, Friederichsen, Keller, & Rosenberg, 2014, p. 37f.)

4.4.1.3 Intended Application of Innovation Fields for Lifting Synergies

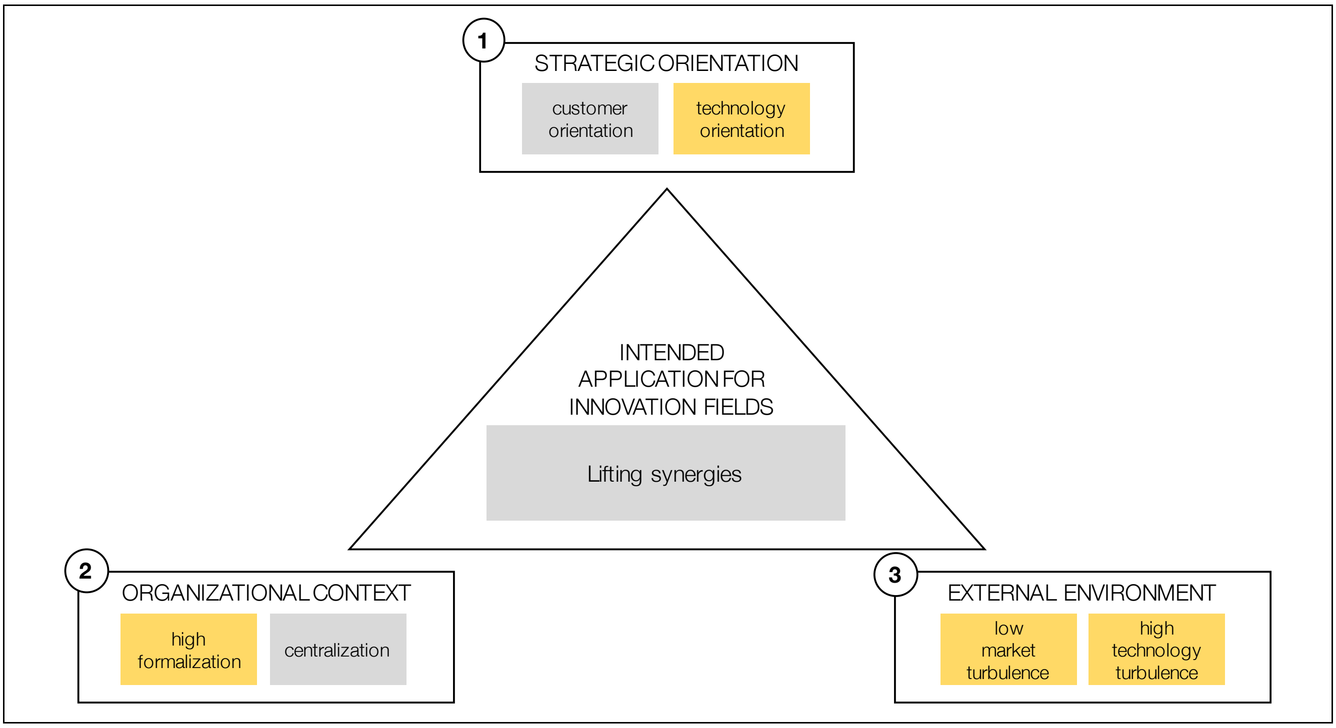


Figure 32: Findings for Intended Application of Innovation Fields for Lifting Synergies

Notes:
Source: own representation

Description of Intended Application

Lifting synergies include (1) fostering the discovery of similar topics through increased transparency and (2) collaborating with other departments or customers on similar topics, complementing each other's competencies.

> *"Innovation fields can give a good overview – it can have a good impact on the organization. […] Linking innovation fields with our scientific partnerships makes much sense to discover relations previously unknown. […] For network purposes and the discovery of synergies, it is very good to link ideas with innovation fields."* (interviewee 19)

For interviewee 9, innovation fields are used as an instrument to collaborate with customers: *"We have some innovation fields defined in cooperation with the corresponding customers, where we try to exchange knowledge at least once a year."* Interviewee 19 uses them primarily for internal collaboration: *"For lifting synergies, [innovation] fields are well suited, so that two [topics] can collaborate"* (interviewee 17).

Interviewee 18 emphasizes the improved internal communication: *"Currently, we are using innovation fields in order to create internal clarity and transparency. Which topics are important to us? Where do we want to generate ideas? Where do we want to start future activities? So, we actually use it for our internal communication […] I like the idea to have the possibility to create transparency at an early stage and to get into contact with others"* (interviewee 19).

Perceived Contextual Factors

Using innovation fields for lifting synergies is related to (1) technology orientation, (2) high formalization, (3) low market and high technology turbulence.

Strategic Orientation (1)

According to interviewee 17, they do involve their customers, albeit not to a high degree and they rather collaborate with other departments in the R&D division. Interviewee 18 supports the technology-orientation with the following statement: *"We drive topics from a technology-perspective."* One possible explanation is that the opportunity space is larger with a technology orientation due to less specific requirements from customers. Innovation fields might thus be perceived as supporting guidance. Furthermore, discovering innovation fields of other departments can help to uncover new opportunities and similar technologic topics that were not previously known. A study by Rein (2004) showed that lifting synergies is particularly helpful when there is an underlying technology orientation to ensure that knowledge of other functional areas is considered when defining or elaborating studies in the front-end of innovation (Rein, 2004, p. 42).

Notably, three out of four respondents belong to Unit 2: Software Systems. This might indicate that there is a difference between software-related projects and other engineering and science projects in the corporate R&D division. Scholars have been trying to grasp the essential differences between software development work and other engineering projects. The main differences cover (1) complexity, (2) flexibility and (3) invisibility. Software projects are described as more complex than other engineering projects due to their dependence on hardware development and since written code is not repeatable (Brooks, 1987, p. 13). Furthermore, unlike finished manufactured projects, software can always be changed and adapted and needs to be maintained accordingly (Brooks, 1987, p. 14). The progress of software development is not physical; thus the progress is not observable like in other engineering projects (Brooks, 1987, p. 14). Software engineers are also called knowledge workers since the software domain is very knowledge-intensive. Furthermore, the field of software engineering is very vast, requiring the collaboration of several different software engineers for almost any given project (Desouza, 2003, p. 99). Additionally, the way in which software engineers work differs profoundly from other disciplines and has developed over time. One common way of working is the so-called *agile* software development with methods like *SCRUM*, relying primarily on iterative feedback loops, self-organized task distribution and completion, with the objective of increasing speed in software development (Dyba & Dingsoyr, 2008, p. 836). Thus, there is evidence indicating that software engineers use innovation fields in a different way to other engineers and scientists in the corporate R&D division.

Organizational Context (2)

Although changes have been made to the innovation management approval process, granting more autonomy to employees of Unit 2: Software Systems, centralization does not exhibit a distinctive characteristic. Interviewee 19 explains the difference: *"The unit head determined that all approvals regarding the first and the second gate of the innovation process are made one executive level below."* Usually, at the corporate R&D division, team leaders approve budget and resources of the first gate, while department heads approve the budget and resources of the second gate (approval for a practical feasibility study). The new approval process appoints first gate decisions to IMA, while the team lead decides second gate decisions. Thus, the question remains whether a connection exists between the low centralization and intended application of innovation fields for lifting synergies.

The formalized context is described through high requirements in a very early stage of the idea, e.g. costs have to be estimated although the process only actually calls for the development of the concept (interviewee 18). Furthermore, the formalized context is described by the decision against ideas that are too far away from the current activities of internal customers (interviewee 19). *"Such attempts fizzle out […], although this might have been a project where we could have collaborated across departments"* (interviewee 19). This declaration indicates that although changes to the approval management have been made, the formalized context impedes explorative studies. In the context of using innovation fields for lifting synergies, high formalization reduces divergent guidelines and perspectives for identical tasks (Auh & Menguc, 2007, p. 1025) and provide the basis for collaboration and lifting synergies. In a study by Teller et al. (2012), it could be shown that formalization supports synergies in a project portfolio (Teller, Unger, Kock, & Gemünden, 2012, p. 603). Synergies can be leveraged through the formalized coordination of information and resource allocation (Teller et al., 2012, p. 603). This relationship is strengthened when the complexity of projects increases. In a study by Rein (2004), formalization in the front-end of innovation led to a greater interaction rate between different functional areas, thus increasing productivity and lifting synergies (Rein, 2004, p. 41).

External Environment (3)

Market turbulence is perceived as low, while technology turbulence is perceived as high. A field note and strategy document of Unit 2: Software Systems underline this finding due to reporting of tremendous novelties in the software industry, such as the *Internet of Things*[18] (field note, June 2013). Software is seen as one of the major enablers of IoT and the area in which most business value will be created (Atzori, Iera, & Morabito, 2010, p. 2883; Manyika et al., 2015, p. 105). At the same time, the complexity of the software systems is dramatically increasing (Manyika et al., 2015, p. 6) and technological advances will only be possible through "[…] synergetic activities conducted in different fields of knowledge, such as telecommunications, informatics, electronics and social science" (Atzori et al., 2010, p. 2878). Thus, it is increasingly important for Unit 2: Software Systems to lift the synergies to develop IoT-related software, explaining the high turbulence at the same time. Additionally, they are under much pressure to hold and extend their competitive advantage regarding technology development, while major opponents arise, especially in the US and Asia (IoT Analytics, 2015, p. 6). The trajectory of IoT is predicted to be as drastic as the development of the software industry in the 1990s (Iyer, 2016).

---

[18] The Internet of Things is defined as "sensors and actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines"(Manyika et al., 2015, p. 1).

Conclusion

- Using innovation fields for lifting synergies implies (1) finding similar topics through increased transparency and (2) collaborating with other departments on similar topics.
- Using innovation fields for lifting synergies occurs more likely in a formalized and technology-oriented context with low market and high technological turbulence.
- Using innovation fields for lifting synergies seems to be important for Unit 2: Software Systems.

4.4.1.4 No Intention to Use Innovation Fields

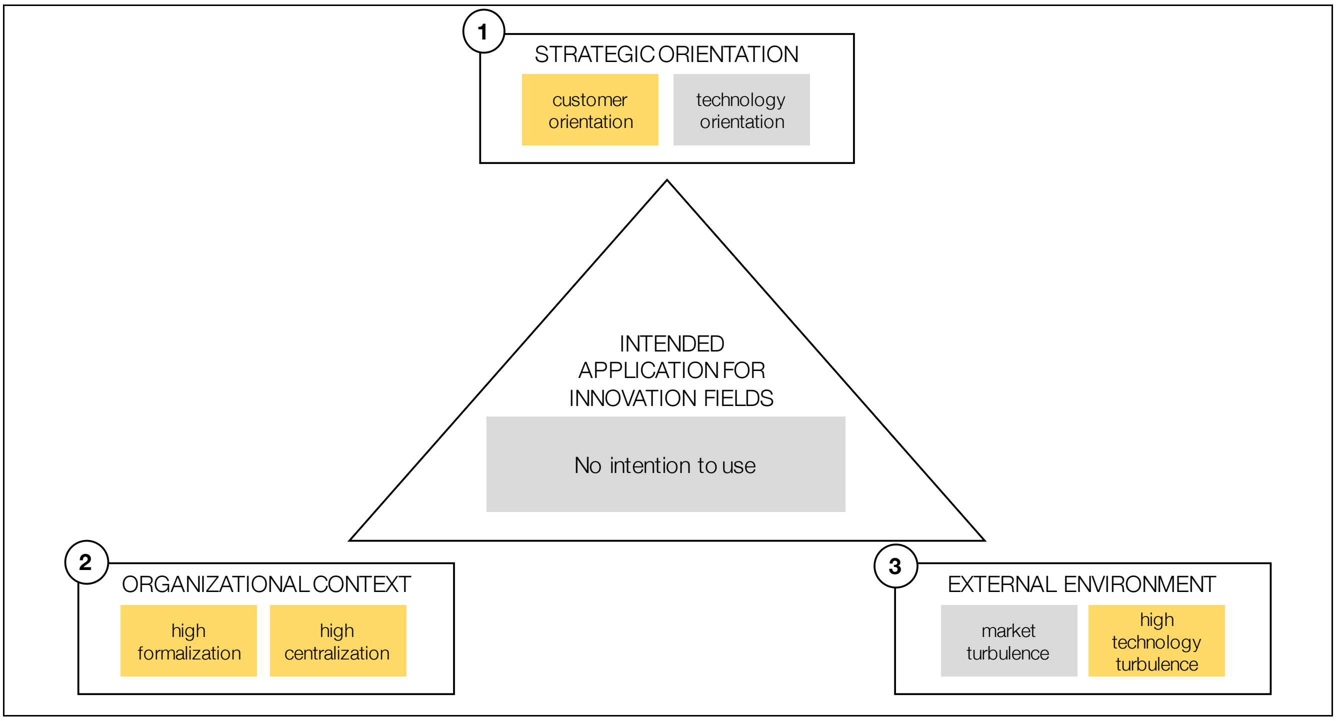


Figure 33: Findings for No Intended Usage of Innovation Fields

Notes:
Source: own representation

The largest sub-sample in the qualitative study reports having no intention of using innovation fields. This could be due to the fact that innovation fields had only recently been introduced and implemented within the organization (interviewee 20). However, the respondents also delivered specific reasons for the non-usage of innovation fields. These reasons can be grouped into three main areas: (1) customer requirements as a sufficient scoping mechanism of innovation activities, (2) no additional benefit of innovation fields due to a sufficient scoping of current activities and (3) the perceived insufficient definition and acknowledgement of innovation fields. These reasons will be discussed in detail in the following. The contextual factors for this behavior unfold in customer orientation, a formalized context, high centralization, and rather high technology turbulence.

Customer Requirements as a Sufficient Scoping Mechanism of Innovation Activities (interviewee 1, 15, 21, 22)

Four respondents mentioned that the proximity to the internal customer (business division) is a sufficient scoping mechanism, rendering innovation fields obsolete.

These respondents stated that they are sufficiently guided through their customers and do not perceive innovation fields as additional support. *"We do not use them because we do have many good ideas from outside [from internal customers, the business divisions]"* (interviewee 22). Interviewee 21 states that the department does not intend to use innovation fields because the direction and focus are clearly given through the portfolio of the internal customers. Interviewee 1 states that the customer's product defines the search scope and therefore innovation fields have no impact: *"We have particular topics we are working for. That is fairly simple: we have a goal, defined by the particular product. It is probably more difficult for the departments in the technology research area that do research on new materials. […]. However, we know exactly where to search for new ideas. We only defined the innovation fields because we had to"* (interviewee 1).

Notably, all three interviewees of Unit 3: Consumer Goods are within the non-usage cluster and all three mention that through having sufficient guidance through their internal customers, they do not need innovation fields as an additional search boundary for their daily work. Getting precise directions from internal customers in a rather formalized and centralized context could indicate that the opportunity space is already limited. Having additional guidelines through innovation fields in the front-end of innovation might be considered as an innovation inhibitor that further reduces the search scope.

The respondent from Unit 1: Mobility Systems reports that his department is very well scoped through clear requirements of their customers, although the interviewee states that an additional innovation field might be helpful for widening the current search scope and extend their portfolio (interviewee 15). Thus, he perceives innovation fields as an instrument to extend the current portfolio withstanding the given search directions through the requirements of the customer.

No Additional Benefit due to Sufficient Scoping of Current Innovation Activities (interviewee 10, 12, 16)

Interviewees 16 and 12 interpret innovation fields as a theoretical model for their actual working habits: *"In my opinion, we now have a theoretical model that explains our practical work, but with this model, we did not do a step forward"* (interviewee 16). *"[Innovation fields are] another system on top of all the other ones that already exist. We have so many 'boxes*[19]*', and the perception is that it is just one more box"* (interviewee 12). These statements suggest that innovation fields were only set up to fulfill the central requirements for the R&D division, but are not seen as helpful for setting search boundaries or scoping activities.

[19] For example, other types of clustered projects and activities such as strategic programs with pre-determined additional budget and resources, allocated by the head of the corporate R&D division.

Some respondents said that they do not perceive innovation fields as helpful since their current activities are sufficiently scoped:

> *"Most of my colleagues say that it is another unnecessary tool. I think they have to get used to it. Much of the uncertainty derives from the unclear meaning. Most of my colleagues are like: 'What do I have to do now'? We think that up to this point, we did not miss any trends or technologies. Therefore we do not need innovation fields."* (interviewee 10)

This statement indicates that the formalization and centralization are perceived as high. They already have many process requirements in place, while innovation fields are perceived as an additional burden to the work-load and enforcing less autonomy for their work. For interviewee 10, the establishment of innovation fields equals the accusation that the department must have missed technological advancement or trends in the past, whereby innovation fields are perceived almost as a sort of penalty.

Notably, two out of three respondents belong to Unit 4: Materials & Sensors. The sufficient scoping of activities might be due to the distinct topic on which they are conducting research: "*For us, it was always very clear: we are a department for sensors, and this field is very explicit. […] We scan in the sensor area with the perspective: what could we transfer into a relevant product? That is our huge innovation field*" (interviewee 12).

Another explanation might be the high technological turbulence, especially for Unit 4: Materials & Sensors. One possibility might be that innovation fields are perceived as too inflexible for this unit since the sensor industry is one of the fastest-developing industries, especially influenced through the IoT, with an increasing number of various use cases for sensors (Manyika et al., 2015, p. 51). Sensor prices dropped by 30-70% from 2010-2015 (Manyika et al., 2015, p. 11), increasing the pressure to sustain and the technological advancements prior to other manufacturers.

Perceived Insufficient Definition and Acknowledgement of Innovation Fields (interviewee 2, 3, 5, 20)

Interestingly, some of the respondents stating that they do not intend to use innovation fields actually see the benefits for their department very clearly, but are skeptical of their actual impact. Interviewee 2 reports that the unit head does not perceive the need to use innovation fields, although he thinks they are very useful: *"I like the idea of the innovation fields if they were used in their original meaning. Upfront, I have to do strategic planning, then I can expect good results. Having strategic guidelines and using them for ideation helps and motivates a lot"* (interviewee 2).

Another reason for the intended non-usage of innovation fields lies in the definition and suggested application of innovation fields in the respective department:

> *"The way we depicted them […] they do not serve their purpose. Global trends [too broadly defined innovation fields] […] do not help us. We need a conversion from level 1 [very broad fields] to level 3 [very narrow fields]. We have a vision and mission, but they are too big to work with. There is a gap to our activities. The search for new ideas is a problem because innovation fields do not exist. We cannot determine the future of our company out in the open country [without search boundaries]. Depending on the*

competencies and derived from business field analyses, there should be innovation fields, to focus on. […] This part is missing." (interviewee 5)

Interviewee 5 states that they need innovation fields for strategic guidance, although the way in which the department head defined them does not serve this purpose. The non-usage, in this case, is influenced by high centralization. Interviewee 5 reports that neither the IMA (the interviewee) nor the group leaders were involved in the definition of innovation fields and that solely the department head decided on the fields. He states that "*in this case, we really missed the chance to define innovation fields for our department and future research."*

Similarly, interviewee 3 misses more depth in the definition of innovation fields: "*What I am missing are visions that are behind the innovation fields. Innovation fields help me define guidelines, but I think we must sell this better: Why are we covering this topic? We need to inspire people to get their motivation."*

Furthermore, innovation fields seem to be interpreted as an instrument for guidance to prevent the department from generating ideas outside of defined innovation fields: *"In our department, people do not invent something that does not fit our competencies. In my understanding, that is what they [innovation fields] should do. Making sure that we do not have ideas that do not fit"* (interviewee 20). The interviewee also notes that innovation fields only have only recently been implemented and that the employees are not sure yet how they will work in practice.

Conclusion

- For not using innovation fields three main reasons have been detected: (1) customer proximity perceived as sufficient scoping mechanism of innovation activities, (2) no perceived additional benefits due to sufficient scoping of current innovation activities and (3) perceived insufficient definition and acknowledgement.
- Especially Unit 3: Consumer Goods, Unit 1: Mobility Systems and Unit 4: Materials & Sensors have no intention to use innovation fields.

4.4.2 Secondary Intended Applications of Innovation Fields

Besides the explication of primary applications, several interviewees mentioned secondary applications for innovation fields.

Interviewee 4 – indicating the primary intended application of innovation fields for strategic purposes – describes **ideation** as an application of secondary importance: *"I think, we have to meet up for an afternoon or the whole day to look for new ideas [in the specific innovation field], or we have to establish the exact meaning behind it. What we currently have is a slide [with the described fields] […]"* (interviewee 4).

Besides the strategic focus, interviewee 14 describes another way to use innovation fields: *"We do not only have innovation fields that we completely dominate, but also ones that we do not have any competencies yet, respectively building them up. […] And then we have one established innovation field"* (interviewee 14). What the interviewee describes as a secondary application is the distinction of established innovation fields and those beyond the current scope of business. Established innovation fields are those with existing knowledge in the organization, whereas fields beyond the current scope entail building up new competencies. This type of application corresponds to the so-called *grey and white spaces* described by O'Conner and Ayers (2005). Grey and white spaces are search boundaries across and between the current scope of business, targeting new business domains (Colarelli O'Connor & Ayers, 2005, p. 25). In this case, innovation fields are used to build up ambidexterity, with established knowledge domains that are further exploited, and new knowledge domains that will be explored. This describes the intended application of innovation fields for deliberate **portfolio extension**.

All interviewees who reported using innovation fields for technology intelligence, also apply it for **strategic purposes** as a secondary type of application. Interviewee 6 states that innovation fields serve as useful guidelines for employees to detect weak signals that have a strategic fit to the company's strategic and technological profile, while interviewee 13 highlights the benefit that the strategy can be communicated through innovation fields and that this transparency reveals connections to other departments.

Notably, the intended application of innovation fields for technology intelligence has a link to the intended application for strategic purposes. This can be explained by the search behavior of the technology research area, which might differ from the search behavior of the system research area. As indicated earlier, the technology research area mainly seeks use cases for its technologies. They discover new technologies and need to transfer the benefits of such technology to a use case. Therefore, innovation fields might help to give structure by (1) linking weak signals to existing innovation fields and (2) giving some structure for possible search boundaries. Departments in the technology research area can try to integrate their technologies into innovation fields, link weak signals to it and receive feedback from their customers on it.

Interviewees describing intended application of innovation fields for lifting synergies as a primary intended application, mentioned strategic purpose and technology intelligence as secondary applications ideation.

Three interviewees who reported no primary application for innovation fields list secondary applications for innovation fields. Two respondents from Unit 4: Materials & Sensors (interviewee 12 & 16) list lifting synergies as potential applications: *"In our last department head meeting, it was decided to foster interdisciplinary collaboration. We are not sure how to organize it, but we can imagine creating a common innovation field […]"* (interviewee 12). Interviewee 10 thinks that innovation fields might be a good solution for strengthening focus: *"In our group - we are one of the youngest groups in the [corporate R&D division] – there are many employees that have not been with us for a long time, which means that we often think: What does the corporation need?"*

Interestingly, two types of applications for innovation fields were only mentioned as secondary applications: ideation and portfolio extension. Since they were only considered as potential applications, the role of contextual factors for this type of application cannot be drawn. Furthermore, it seems that innovation fields might be used for several types of applications with a different prioritization.

The next chapter reflects on the findings from the qualitative study and draws general conclusions to be further examined in the quantitative study.

4.5 General Conclusions of Qualitative Results

Figure 34: Overview of Qualitative Findings

Notes:
Source: own representation

Although the conclusions drawn from this study "cannot be generalized to populations of firms or markets" per se (De Massis et al., 2013, p. 16; Harrison & Kjellberg, 2010, p. 786), this study provides insights into (1) how innovation fields are applied and (2) how contextual factors influence the intended application. Furthermore, the explorative nature of this study helps to (3) "shape the choice of variables and hypotheses" and (4) grasp "less easily measurable factors" and background information that cannot be achieved through quantitative research (Henderson & Cockburn, 1996, p. 39).

Types of Intended Applications

50% of the respondents (n=11) declared a strong intention to apply innovation fields. Three types of primary applications could be identified, namely strategic purposes, technology intelligence and lifting synergies. Interestingly, ideation and portfolio extension were only mentioned as secondary applications. Portfolio extension is described as guiding activity beyond the current scope of business while using innovation fields for ideation is described as an instrument to manage and generate ideas: *"Desirable would be to take one of those topics [innovation fields] and to do a workshop with it. […] That means to actively shape the process with them [innovation fields] and take them as an auxiliary tool to trigger ideas in this field"* (interviewee 18).

Since ***ideation and portfolio extension*** *were only mentioned as secondary* applications, *further analysis in the quantitative study is needed to learn more about the contextual factors influencing these applications.*

Notably, the intended application of innovation fields for technology intelligence seems to be linked to the intended application for strategic purposes. All respondents intending to apply innovation fields for technology intelligence mentioned strategic purposes as an application of secondary importance. Interviewee 6 states that innovation fields serve as useful guidelines for employees to detect weak signals that have a strategic fit to the company's strategic and technological profile. Table 15 compares the different types of applications from the literature and the qualitative study.

Applications from literature	Applications from qualitative study
Strategic purposes	Primary application
Ideation	Secondary application
Lifting synergies	Primary application
Technology intelligence	Primary application
Portfolio extension	Secondary application

Table 15: Comparison of Innovation Field Applications from Literature and Qualitative Study

Notes:
Source: own representation

Furthermore, the largest sub-sample (n=11) reported having no intention to use innovation fields. Several notes have to be made regarding this finding. First, the qualitative study was conducted at the beginning of the implementation phase of innovation fields at the R&D division. Thus, the reported non-usage might change over the course of time, leading to different results in the quantitative study. Second, since existing literature only reported on the application of innovation fields at the firm level, without indicating the actual application and usage at the individual level, the general intention to use innovation fields needs to be further examined to indicate what contextual factors influence the general intention to use innovation fields.

General intention to use innovation fields *will be further considered in the quantitative study to enhance the understanding of what contextual factors influence the intended application of innovation fields at the individual level.*

An additional aspect regarding the application of innovation fields is the prioritization of the different types of innovation field applications. As outlined by the findings, interviewees report an intended primary application as well as applications of secondary importance. Thus, the question arises concerning which applications are most relevant in the context of this research setting and should be further examined.

A ***ranking of types of intended applications for innovation fields*** *in the quantitative study will offer insights into their prioritization.*

Strategic Orientation

Customer orientation was an influencing factor for technology intelligence and the non-usage cluster, while technology orientation was high for lifting synergies. Customer orientation captures the understanding of customers to create valuable products fulfilling their needs (Narver & Slater, 1990, p. 21), while technology orientation is "the ability and will to acquire a substantial technological background and use it in the development of new products. Technology orientation also means that the company can use its technical knowledge to build a new technical solution to answer and meet new needs of the users" (Gatignon & Xuereb, 1997, p. 78). Besides the orientation towards customers or technology, some respondents reported another dimension of orientation, namely if their innovation activities go beyond the current of business and competencies: "Currently, most of them [innovation fields] lie within our competencies. However, we do have two broader ones that are overarching" (interviewee 8).

Interviewee 1 states that their innovation fields exclusively focus on their core competencies, while interviewee 12 states that they also address their competencies, but are still sufficiently comprehensive to ensure building up new competencies. Hence, the orientation towards the exploitation of own competencies or the exploration of new competencies might be an orientation that influences the intended innovation field application (Jansen et al., 2006). This orientation directly relates to the search strategy, boundaries and scope of innovation activities and should be put into consideration. The strategic orientation towards exploitation or exploration needs to be distinguished from the overarching goal of companies becoming ambidextrous as a whole and indicates the perceived orientation of innovation activities in the respective department or research unit solely.

To measure the influence of the search strategy and boundaries on innovation field applications, ***exploration and exploitation*** *will be included as influencing factors in the quantitative study.*

Organizational Context

Formalization shows to have an impact on all four intended applications and is described as high for all applications. Centralization shows an impact for technology intelligence and the non-usage cluster and is described as low for technology intelligence and high for the non-usage cluster.

Interestingly, the intended application for innovation fields congregates around specific units, primarily Unit 2: Software Systems, Unit 5: Components & Simulation and Unit 6: Manufacturing Technologies. The non-usage clusters concentrate around Unit 1: Mobility Systems, Unit 3: Consumer Goods and Unit 4: Materials & Sensors.

Unit 5: Components and Unit 6: Manufacturing Technologies both belong to the technology research area. As described in Chapter 4.4.1.1, their focus is the discovery, technical configuration, and implementation of new technologies into existing or new products. This working habit is frequently described as "a solution seeking for an appropriate use case" (field note, March 2013). Unit 5 uses innovation fields primarily for strategic purposes while Unit 6 uses them mainly for technology intelligence.

The non-usage cluster primarily comprises departments belonging to the *system research area*, which primarily designs and constructs components and products for the business divisions. Furthermore, it could be detected that Unit 4: Materials & Sensors does not intend to apply innovation fields. For Unit 4, two explanations might describe the reasons for the non-usage. First, the unit is very customer-oriented and very close to the customer. Sensor development is very well aligned with the customers and a field that is well-defined and scoped. As interviewee 1 stated: *"It is probably more difficult for the departments that do research on new materials. […]. However, we know what we have to look at."* Second, for Unit 4: Materials & Sensors, innovation fields might be too inflexible, since technology turbulence is perceived as high: *"Sensors is such a big field, and new sensors are coming up on a daily basis […]. It can be said that regarding new products, we will not run out of work in the foreseeable future"* (interviewee 12). One unit in the technology research area, specifying the use of innovation fields is Unit 2: Software

Systems. They intend to use innovation fields for lifting synergies. As discussed in Chapter 4.4.1.3, the way in which software is developed and software projects work might differ from the working habits in other units.

A relationship between the intended applications of innovation fields and the ***unit affiliation*** *is proposed and will be tested in the quantitative study by integrating the unit as a control variable.*

Furthermore, working for the technology research area is described with a different working habit ("technologies searching for a use case") by several respondents. Working for the technology research area requires excessive information input and dedication to new trends and technological advancements, while at the same time a constant transfer to potential products or use cases. This behavior can be best described by the screening of opportunities as a variable to detect innovative behavior in the front-end of innovation. The way in which information is discovered and decided upon in the initial stages is described by "intelligence generation and dissemination" tantamount to opportunity screening (Hüsig et al., 2005, p. 861; Jaworski & Kohli, 1993, p. 56; Zaltman, Duncan, & Holbek, 1973, p. 62).

To detect the mode of working for the technology research area in the front-end of innovation and relate it to intended applications of innovation fields, ***opportunity screening*** *will be introduced in the quantitative study.*

Surprisingly, several statements in the qualitative findings evolved around interdepartmental dynamics, especially interdepartmental connectedness, "[…] which refers to the degree of formal and informal direct contact among employees across departments" (Jaworski & Kohli, 1993, p. 56). As interviewee 17 states: *"Collaboration is very important, but oftentimes, their start is dependent on the effort and the network of the individuals"* (interviewee 17). Several respondents claimed that collaboration between departments is crucial for successful projects, but is also challenging for different reasons, such as limited time for cross-department activities (interviewee 2), strict thematically-divided department boundaries (interviewee 10) and formal difficulties, e.g., the internal funding and accounting of joint activities (interviewee 16, 11). Interviewee 9 describes collaboration as topic-dependent and claims that joint activities are fundamental for topics like the Internet of Things (interviewee 9). Being linked enables greater cooperation and synergy and the exploitation of discovered information, which is essential in the front-end of innovation (Zhang & Doll, 2001, p. 100). Although this contextual factor was initially evaluated as holding less importance when setting up the general framework, the above-mentioned statements clearly indicate the need to elaborate further on the potential influence of connectedness to applications of innovation fields.

To estimate the influence of interdepartmental connectivity towards innovation field application, ***connectedness*** *will be added to the framework as an additional contextual factor.*

External Environment

Market turbulence is described as an influencing factor for the intended application for strategic purposes, technology intelligence and for lifting synergies and is always characterized as low. On the other hand, technology turbulence is a relevant factor in all four clusters, with a high characteristic for strategic purposes, synergy lifting, and the non-usage cluster, while it is reported as low for technology intelligence. While turbulence captures the intensity of advances technology-wise or in the marketplace, it does not capture the current state, such as competitive intensity and landscape. However, competitive intensity affects profit and can lead to imitative behavior

(Porter, 2008, p. 85; Zheng et al., 2005, p. 47). To avoid imitation, it holds particular importance to the R&D sector to provide cutting edge systems and technologies to sustain the competitive advantage regarding other players in the market. This was also expressed by some respondents, who claimed (1) that unique benefits of innovation activities in relation to competitors have to be defined very early on within the process for an idea to be further elaborated (interviewee 12, 15) and (2) the competitive landscape holds strong importance, especially when entering new territory or developing a new innovation strategy (interviewee 22, 2).

*Thus, **competitive intensity** will be integrated as an additional contextual factor to capture its influence on intended innovation field applications.*

Several respondents declared their dissatisfaction with the innovation process. They considered the process as either too hieratic and bureaucratic (interviewee 2, 10), too complex and unintuitive (interviewee 10, 16) or too time-consuming (interviewee 15), leading to a high degree of frustration. Naturally, when satisfaction with the overall process is low, the intended application of innovation fields might suffer from it. When adapting internal processes, employee satisfaction holds importance when designing or changing deep-rooted work patterns (Julian Birkinshaw, Hamel, Mol, & Mol, 2008, p. 829; Hüsig et al., 2005, p. 865).

***Process satisfaction** is added as a control variable to assess its impact on the intended innovation field application.*

The next table provides an overview of the identified variables in the qualitative study and the added variables to be followed up in the quantitative study.

	Contextual factors in the qualitative study	**Additional contextual factors in the quantitative study**
Strategic orientation	Customer orientation Technology orientation	Exploration Exploitation
Organizational context	Formalization Centralization	Opportunity screening Connectedness
External environment	Market turbulence Technology turbulence	Competitive intensity
Additional factors		Unit affiliation Process satisfaction

Table 16: Overview of Additional Influencing Factors for Quantitative Study

Notes:
Source: own representation

The conduction of the qualitative study only revealed findings related to the first research question on the role of contextual factors on intended innovation field applications. Since the interviews were held shortly after introducing innovation fields at the R&D division, the proficiency of innovation fields was not considered. The quantitative study conducted 12 months after the qualitative study, will additionally examine the second research question.

In the following, a more detailed and large-scale analysis is carried out through a quantitative survey of innovation field applications and the contextual factors used in the qualitative study, complemented by the additionally-defined contextual factors.

The quantitative analysis extends beyond the cross-case synthesis drawn by this study. The interviews serve as embedded units of analysis for the behavior of the whole R&D division regarding innovation field application. “The findings and conclusions would then require separate data from the broader or larger unit of analysis that serves as the main case, in addition to cross-case data from the multiple case studies” (Yin, 2014, p. 167).

5 Study 2: Quantitative Study

The purpose of the quantitative study is to validate and enhance the research framework from the qualitative study with the presented types of innovation field applications and contextual factors with a larger sample size, but in the same context (R&D setting). The quantitative study is the second phase of the mixed-method research approach and concludes the data collection for the embedded single case design. The underlying questions to be answered in this explorative study are: (1) how and why do perceived contextual factors influence the intended application of innovation fields and (2) how and why do perceived contextual factors influence the perceived proficiency of innovation fields? The next chapter explains the conduction of the quantitative study, explicates the measures, and presents the findings. First, the data collection is introduced, and the sample is described, after which the measures are explained. Thereafter, the data analysis is explained, and biases are analyzed. Subsequently, the findings are presented according to the different types of applications for innovation fields and the perceived proficiency of innovation fields. Finally, general findings are described. The following figure shows the structure of the chapter.

STRUCTURE OF CHAPTER 5: STUDY 2: QUANTITATIVE STUDY

Figure 35: Chapter Overview of Quantitative Study

Notes:
Source: own representation

5.1 Data Collection

All constructs[20] used in the quantitative survey are well-established multi-item scales from literature (Churchill, 1979, p. 66; Churchill & Peter, 1984, p. 366). Since this study is of explorative nature, constructs from related studies were taken to measure the impact of diverse contextual factors on the individual intended applications of innovation fields and their perceived proficiency to enhance performance and innovativeness. Furthermore, multi-item constructs were used, proving more reliable and ensuring that the underlying study complies with scientific standards (Bruner & Hensel, 1993, p. 341; Churchill, 1979, p. 66; Helfat & Peteraf, 2003).

Since this study shall analyze the subjective experience and judgement of contextual factors and thus the perception of those factors, rating questions measuring the intensity of judgments are the appropriate choice. The most renowned version is known as the Likert scale (Saunders et al., 2009, p. 378; Teo, 2013, p. 11). When using Likert scales, three decisions have to be made: (1) the total number of categories, (2) even or uneven category numbers and (3) forced versus non-forced answers (Malhotra, 2006, p. 87). As outlined by Malhotra (2006), there is no optimal number of categories, although a range of five to nine categories is deemed the best option and constitutes what the majority of empirical studies use. For this study, all items were measured with a seven-point Likert scale. An uneven number of answer choices was selected to give a neutral answer option to respondents. Furthermore, a *not applicable* field was offered. Making answers forced likely leads to a bias among respondents choosing the neutral category. Thus, with non-forced answers, the accurateness of data is improved (Malhotra, 2006, p. 87f.). The categories were labeled from 1 = *strongly disagree* to 7 = *strongly agree*, which are commonly-used scale ratings (Saunders et al., 2009, p. 380).

Since the survey was composed in German, a translation of the English items into German was needed. Therefore, the items were re-translated from the original language (English) into German (the so-called *back-translation approach*) and translated back into English by a second person (Banville, Desroisiers, & Genet-Volet, 2000, p. 378; Pook, Tuschen-Caffier, & Kaufmann, 2006, p. 402). For the purpose of this survey, all items were re-translated by a German person with excellent English skills and additionally checked by an interpreter for English and German to ensure accurate formulation. Upon comparing the German and English versions, no perceivable differences in the items were recognized. For the underlying purpose of this study, items were adapted to the context of the survey as far as needed[21]. The original and translated versions of the items as well as the source of the original items can be seen in Appendix A06.

To ensure the validity of the questionnaire and to check its length and duration, a pre-test was conducted before the survey was sent out. First, the survey was discussed with a group of PhD students of the corporate R&D division in a workshop. After adding the feedback, the survey was tested with a representative sample recruited from the R&D division (n = 7). For the pre-test, it is crucial to discover problems of comprehensible nature, such as

[20] Constructs are understood as the operationalized variables, which comprise several items.
[21] For confidentiality reasons, the company name and company-specific terms were blinded and generalized in the reporting of the items.

misinterpretations, ambiguous questions, duration and practical feasibility (Hunt, Sparkman, & Wilcox, 1982, p. 270). Therefore, these tests were performed in a face-to-face setting (Bolton, 1993, p. 281). After the pre-test, the questionnaire was slightly adapted after the responses from pre-testers and instructions were clarified.

Within the qualitative study, a representative sample from the corporate R&D division had been interviewed. For the quantitative study, all employees from the corporate R&D division in Germany have been invited. The sample of the qualitative study was integrated into the sample of the quantitative study, ensuring inferences from both studies and the transferability of results (Onwuegbuzie & Johnson, 2006, p. 56).

The questionnaire was developed with the company's internal online tool *Inquery*, including nine dependent variables (27 items), eleven independent variables (41 items), five control variables (6 items) and two descriptive variables (3 items), adding up to 77 items. Besides the items to answer the research questions, the survey also contained some items for company internal purposes[22]. The questionnaire can be found in Appendix A05.

The link for the survey was sent out via an invitation email, explaining the purpose of the study and containing the link to the survey[23]. In total, the survey was sent to N = 1,314 people in two batches[24]: the first batch included 698 people, the second batch 594 people. Twenty-two email addresses were invalid, resulting in an adjusted N = 1,292. The survey was open for seventeen days between March 26 and April 11, 2014. 575 people opened the questionnaire, out of which 443 participants answered, resulting in a response rate of 34.3%. After the list-wise deletion of questionnaires with missing values of more than 10%, n = 389 questionnaires could be used for analysis, which corresponds to an effective response rate of 30.1%. The response rate is considered high since an increasing number of studies are conducted and response rates have been decreasing. In 1998, response rates from email surveys declined from 46% to 31% and the trend is assumed to continue (Sheehan, 2001). Additionally, recent studies in innovation management have resulted in response rates between 15% and 39%, supporting the notion that the response rate in the underlying study is high (Baker & Sinkula, 2007; Cardinal, 2001; Gruber, MacMillan, & Thompson, 2013; Kleinschmidt et al., 2007; Poskela & Martinsuo, 2009). The average time for filling out the survey amounted to approximately 25 minutes. A chart displaying the distribution of the full responses is shown in the figure below.

[22] Company internal items were asked for a different context and are not reported here due to confidentiality reasons.
[23] Small merchandising packages were raffled upon completing the questionnaire.
[24] Sending out the questionnaire in two batches was required upon agreement with the workers' council.

Distribution of response rate by date

	Date	Full responses	%	Remark
Week 1	26.03.14	109	24.6%	Email batch 1
	27.03.14	42	34.1%	
	28.03.14	6	35.4%	
	29.03.14	0	35.4%	
	30.03.14	0	35.4%	
Week 2	31.03.14	93	56.4%	Email batch 2
	01.04.14	18	60.5%	
	02.04.14	56	73.1%	Reminder 1 batch 1
	03.04.14	13	76.1%	
	04.04.14	6	77.4%	
	05.04.14	2	77.9%	
	06.04.14	0	77.9%	
Week 3	07.04.14	34	85.6%	Reminder 1 batch 2
	08.04.14	11	88.0%	
	09.04.14	27	94.1%	Reminder 2 batch 1
	10.04.14	20	98.6%	Reminder 2 batch 2
	11.04.14	6	100.0%	
		443	100.0%	

Responses per day	26
Overall response rate	34.3%

Figure 36: Distribution of Full Responses

Notes:
Source: own representation

5.2 Sample Description

The average age of the respondents is 38, with the largest proportion being between 30 and 39 (37.8%). The corporate R&D division has quite young personnel, which is also reflected by the average job tenure at the company: on average, the respondents have been working for the company for 10.2 years, with the largest proportion (38.3%) being at the company for less than five years. These findings are in line with internal figures regarding the tenure and age of the whole population in the R&D division. Since the case is a corporate R&D division, a large part of the personnel has been hired directly after college or PhD programs. Usually, employees stay for three to five years and are then expected to change position towards their internal customers (business divisions). Accordingly, knowledge is constantly refreshed, while the internal customers profit from the networks and knowledge that these employees bring along. However, this also implies that knowledge management and the knowledge about long-term strategic directions of the R&D division are impeded due to the constant fluctuation of employees. This indicates the need for particular attention to knowledge dissemination, ensuring successful transfer of relevant information.

As mentioned in Chapter 3.4.2, the corporate R&D division comprises six research units, which are divided into departments and teams. The questionnaire asked for the unit for which the respondents are working, covering the different research topics. Table 17 visualizes the distribution of the six research units.

Research unit	Questionnaire (n = 389)		Population (N = 1331)	
	No.	%	No.	%
Unit 1: Mobility Systems	61	15.7	246	18.5
Unit 2: Software Systems	68	17.5	210	15.8
Unit 3: Consumer Goods & Building Technology	22	5.7	79	5.9
Unit 4: Materials & Sensors	88	22.6	307	23.1
Unit 5: Components & Simulation	55	14.1	198	14.9
Unit 6: Manufacturing Technologies	87	22.4	291	21.9
NA	8	2.1	0	0.0

Table 17: Comparison of Respondent Distribution and Actual Population

Notes:
Source: own representation
Population status as of April 2013

The table shows a rather homogeneous distribution of areas around 20%, except for Unit 3: Consumer Goods & Building Technology with only 5.7% of respondents being affiliated with this unit. The two largest groups are Unit 4: Materials & Sensors and Unit 6: Manufacturing Technologies, with about 23% of respondents working for each of these units. The distribution corresponds to the whole population, with Unit 6: Manufacturing Technologies (21.9%) and Unit 4: Materials & Sensors (23.1%) being the largest ones and Unit 3: Consumer Goods & Building Technologies (6%) representing the smallest fraction of the corporate R&D division. Therefore, no over-representation of specific areas could be detected.

5.3 Measures

The intended applications are tested through six dependent variables, derived from literature and the qualitative study. These can be divided into the intended application of innovation fields for strategic purposes, portfolio extension, technology intelligence, ideation and lifting synergies. Furthermore, general intention to use innovation fields is tested. Additionally, three variables capturing perceived proficiency for innovation fields are tested, since innovation fields had been implemented for about twelve months at the time of conducting the quantitative study. These three variables comprise overall perceived usefulness, innovation fields enhancing innovativeness and innovation fields enhancing performance. The contextual factors are measured with eleven independent variables. As explained in the previous chapter, the framework described in the qualitative study was expanded by some variables and will be used here.

In the following, the variables are explained in detail, showing the items, and relevant construct statistics with mean, standard deviation, discriminating power and the reliability measure Cronbach alpha. Cronbach's alpha values are acceptable with a score of 0.7 and higher (Lance, Butts, & Michels, 2006, p. 207; Nunnally, 1978, p. 245f.) The discriminating power[25] was calculated, defined as an indicator for ambiguity in items. "A highly discriminating item divides the regions clearly – having a narrow region of ambiguity" (Reckase & McKinley, 1991, p. 362). For this study, the corrected correlation (r.cor) was used, taking into account the item reliability and the fact that the item is part of the construct (Luhmann, 2015, p. 272). Values range between -1 and +1: the higher the value, the better the discriminating power of the item.

[25] The discriminating power was calculated using R with the command 'alpha' displaying various types of discriminating power.

5.3.1 Dependent Variables

To measure different applications for innovation fields and their perceived proficiency, constructs were adapted from the *Technology Acceptance Model* (TAM) (Venkatesh & Davis, 2000), which was originally developed by Davis in 1989 in order to test the acceptance of software systems and to measure the user acceptance of information technology adoption. The constructs were adapted to the scope of measuring the individual intended application of innovation fields as well as their perceived proficiency. Using borrowed constructs has been found to make little difference to constructs developed exactly for the question and discipline of use regarding validity and reliability (Churchill & Peter, 1984, p. 366).

Three main arguments are justifying to the usage of the TAM in this study: first, as previously explained, innovation fields were implemented at the corporate R&D division as an additional instrument to the existing NPD process, whereby they are documented and stored in an internal online information system, which is an IT-based system. Second, studies from Escobar-Rodriguez et al. (2012) and Wangpipatwong et al. (2008) show the use of TAM for IT-close areas such as the use of an e-government website and the acceptance of e-prescriptions in hospitals (Escobar-Rodríguez, Monge-Lozano, & Romero-Alonso, 2012; Wangpipatwong, Chutimaskul, & Papasratorn, 2008). Thirdly, since the study was performed only twelve months after the implementation of innovation fields, the intention to use was searched after, displayed by the original TAM items. The implementation of innovation fields at the R&D division corresponds to the use of the technology acceptance model in the aforementioned studies. The items were adapted to the context of innovation fields and cover the different types of applications derived from literature and qualitative interviews.

The dependent variables are split into three different categories: besides the general intention to use innovation fields, the constructs capture the application for strategic purposes, ideation, lifting synergies, technology intelligence and portfolio extension. Furthermore, three dependent variables measuring proficiency were added: the overall perceived usefulness of innovation fields as well as the increase of innovativeness and performance through innovation fields.

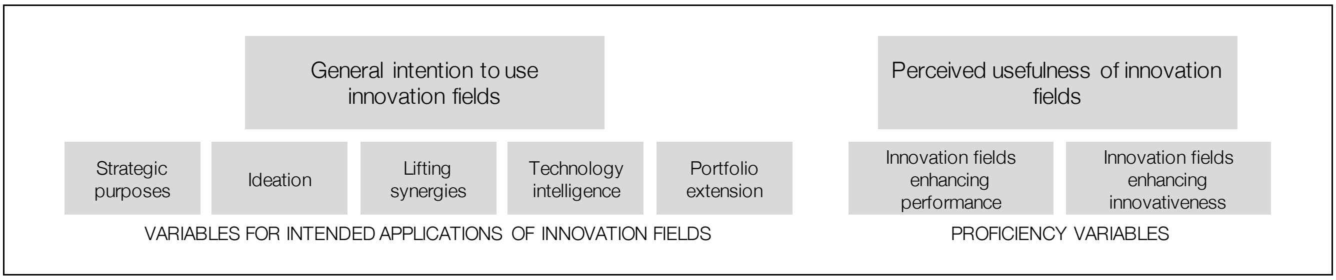


Figure 37: Overview of Dependent Variables

Notes:
Source: own representation

All dependent items measure the intended application, which might not correspond to the actual application. Due to the limited time since the implementation of innovation fields (12 months), the chosen variables display an appropriate measure to cover the intended application of innovation fields.

Variables Measuring Intended Application of Innovation Fields

With the variable **general intention to use innovation fields** (intent), the general intention of using innovation fields is covered, while the variable **intended application of innovation fields for strategic purposes** (use_strat) implies the alignment with corporate goals, the focus of innovation activities and portfolio management. The **intended application for technology intelligence** (use_tec) covers the detection of weak signals, qualitative pieces of information indicating upcoming trends and technological novelties. The **intended application of innovation fields for ideation** (use_idea) implies the application of innovation fields for ideation workshops and as search boundaries for an idea search. The **intended application of innovation fields for portfolio extension** (use_div) measures the discovery of new business segments through innovation fields as well as the facilitation of discovery of radical innovation. The final application-related variable **intended application of innovation fields for lifting synergies** (use_syn) covers the application of innovation fields for collaboration between employees as well as the discovery of similar topics. The item use_div 3 from the intended application for portfolio extension had to be dropped due to poor reliability measure and discriminating power.

The mean of the items lies between 3.34 and 5.49. The discriminating power of all items is above 0.5, and thus the items represent the construct. The reliability measure Cronbach's Alpha, lies above 0.7, displaying good reliability and internal consistency for the constructs. Details are shown in Table 18.

	Label	Dependent variables Text	M	SD	DP	α
General intention		**General intention to use**	4.724			0.894
	intent1	I can imagine using innovation fields in the future.	4.82	1.51	0.86	
	intent2	In the future, I intend using innovation fields.	4.62	1.56	0.86	
Types of applications for innovation fields		**Application of innovation fields for strategic purposes**	5.313			0.789
	use_strat1	Using innovation fields can strengthen the concentration and focus to dedicated topics.	5.33	1.44	0.69	
	use_strat2	Using innovation fields can support the strategic orientation of our department.	5.13	1.52	0.73	
	use_strat3	Innovation fields improve the overview of topics.	5.49	1.36	0.69	
	use_strat4	Innovation fields can help to discover strategic gaps.	4.79	1.64	0.54	
		Application of innovation fields for technology intelligence	4.284			0.831
	use_tec1	Using innovation fields can support me in early technology detection.	4.14	1.59	0.82	
	use_tec2	Innovation fields can help me to assign weak signals.	4.52	1.60	0.65	
	use_tec3	Innovation fields improve the discovery of trends.	4.09	1.67	0.8	
		Application of innovation fields for ideation	4.471			0.783
	use_idea1	Using innovation fields can support me in ideation.	4.13	1.68	0.81	
	use_idea2	Innovation fields are good guiding rails for ideation.	4.44	1.67	0.78	
	use_idea3	Innovation fields are suitable as topics for innovation workshops.	4.85	1.56	0.55	
		Application of innovation fields for portfolio extension	3.896			0.700
	use_div1	Using innovation fields can help to develop a new business field.	4.45	1.59	0.66	
	use_div2	Using innovation fields can facilitate finding radical innovations.	3.34	1.62	0.67	
	~~use_div3~~	~~Innovation fields can be an instrument to execute studies and projects that lie adjacent to the competencies of the department.~~	~~3.93~~	~~1.68~~	~~0.47~~	
		Application of innovation fields for lifting synergies	4.953			0.787
	use_syn1	Innovation fields can help me bring transparency over current and future research topics.	4.97	1.46	0.7	
	use_syn2	Innovation fields can help me discover similar topics.	4.89	1.48	0.77	
	use_syn3	Innovation fields increase the probability to lift synergies between topics.	4.99	1.50	0.66	

Table 18: Item- and Construct Characteristics of Dependent Variables Measuring IF Applications

Notes:
M = mean, SD = standard deviation, DP = discriminating power, α = Cronbach alpha
n = 389 (missings possible)
Answer dimension: 1 = "I fully disagree" to 7 = "I fully agree"

Variables Measuring Proficiency of Innovation Fields

To grasp the perceived proficiency of innovation fields and their contextual factors, three measures have been included: **innovation fields enhancing innovativeness** (use_inno), **innovation fields enhancing performance** (use_per) and overall **perceived usefulness of innovation fields** (perc_use). While innovativeness refers to the perceived degree of novelty of innovation (Garcia & Calantone, 2002, p. 112) triggered by the application of innovation fields, performance captures the perceived proficiency and success. The general usefulness of innovation fields was added to capture the perceived additional benefit of innovation fields, comprising performance, effectiveness, and productivity.

The mean of all items lies between 3.71 and 4.59. The discriminating power of all items is above 0.5, and thus the items represent the construct. The reliability measure Cronbach's Alpha, lies above 0.7, displaying good reliability and internal consistency for the constructs. Details are shown in Table 19.

	Label	Dependent variables Text	M	SD	DP	α
Proficiency-related variables		**Perceived usefulness**	4.056			0.822
		With regards to the development of new products and services, innovation fields can contribute to				
	perc_use1	...the performance, thus the success of the research unit.	3.87	1.55	0.79	
	perc_use2	...the productivity, thus the speed of developing ideas and concepts.	3.71	1.60	0.76	
	perc_use3	...the effectiveness, thus the choice of the right topics.	4.59	1.57	0.69	
		Innovation fields enhancing performance	4.326			0.883
	use_per1	Using innovation fields can increase the performance of the research unit.	4.43	1.54	0.81	
	use_per3	With innovation fields, we can be more effective in the future.	4.56	1.46	0.82	
	use_per2	Using innovation fields can increase the success of the research unit.	4.00	1.48	0.84	
		Innovation fields enhancing innovativeness	3.864			0.760
	use_inno1_re	Using innovation fields has no influence on the innovativeness of the research unit. (reverse coded)	3.98	1.76	0.57	
	use_inno2	As research unit, with innovation fields we are more innovative in the future.	3.84	1.56	0.82	
	use_inno3	Using innovation fields can contribute to the innovativeness of the research unit.	3.73	1.65	0.71	

Table 19: Item- and Construct Characteristics of Dependent Variables Measuring Proficiency

Notes:
M = mean, SD = standard deviation, DP = discriminating power, α = Cronbach alpha
n = 389 (missings possible)
Answer dimension: 1 = “I fully disagree” to 7 = “I fully agree”

5.3.2 Independent Variables

As mentioned above, the independent variables were divided into the categories of (1) strategic orientation, (2) organizational context and (3) external environment.

Strategic Orientation

Strategic orientation is described by Gatignon and Xuereb (1997) as “the strategic directions implemented by a firm to create the proper behaviors for the continuous superior performance of the business” (Gatignon & Xuereb, 1997, p. 78). Four variables regarding strategic orientation were used in the survey, namely **customer orientation** (strat_cust), **technology orientation** (strat_tec), **exploitation** (exploit), and **exploration** (explore).

Customer and technology orientation were adapted as two-item scales from Narver and Slater (1990), which have frequently been used in other studies (Baker & Sinkula, 2007; Gatignon & Xuereb, 1997; Narver & Slater, 1990; Zheng et al., 2005). The exploitation and exploration measures were adapted from the study of Jansen and van den Bosch (2006).

Customer and technology orientation capture whether the strategy is aligned according to customer needs or technological changes. Customer needs are considered as internal customers in this survey, namely the business divisions to which the corporate R&D division caters. Exploration and exploitation were added to measure whether the perceived search strategy, boundaries and scope of innovation activities have an influence on the intended innovation field application. The items used in this study need to be distinguished from the overarching goal of companies to become ambidextrous as a whole and indicate solely the perceived orientation of innovation activities in the respective department or research unit.

The mean of the items ranges between 4.69 and 5.47. The discriminating power of all items is above 0.5, while Cronbach Alpha measures are above 0.7 for all constructs except technology orientation, which is very close to

0.7. Cronbach Alpha analysis suggests the removal of one item from exploitation (exploit7). Details are shown in Table 20.

		Independent variables				
	Label	Text	M	SD	DP	α
Strategic orientation		**Customer orientation**	5.347			0.774
	strat_cust1	Our business objectives are driven primarily by customer satisfaction.	5.28	1.36	0.72	
	strat_cust2	We constantly monitor our level of commitment and orientation to serving customer needs.	5.42	1.30	0.72	
		Technology orientation	5.470			0.693
	strat_tec1	Our departmen uses sophisticated technologies in Its new product development.	5.50	1.45	0.64	
	strat_tec2	The products that we develop are always at the state of the art of the technology.	5.43	1.24	0.64	
		Exploitation	4.692			0.719
	exploit1	We frequently refine the provision of existing products and services.	4.92	1.43	0.56	
	exploit2	We regularly implement small adaptations to existing products and services.	4.04	1.60	0.63	
	exploit3	We introduce improved, but existing products and services for our local market.	5.09	1.25	0.72	
	exploit4	We improve our provision's efficiency of products and services.	5.33	1.26	0.55	
	~~exploit7~~	~~Lowering costs of internal processes is an important objective~~	~~4.54~~	~~1.92~~	~~0.29~~	
		Exploration	5.04			0.791
	explore1	Our unit accepts demands that go beyond existing products and services.	4.82	1.53	0.59	
	explore2	We invent new products and services.	5.11	1.60	0.83	
	explore3	We experiment with new products and services in our local market.	5.16	1.53	0.78	
	explore4	We commercialize products and services that are completely new to our unit.	4.18	1.65	0.52	

Table 20: Item- and Construct Characteristics of Strategic Orientation Variables

Notes:
M = mean, SD = standard deviation, DP = discriminating power, α = Cronbach alpha
n = 389 (missings possible)
Answer dimension: 1 = "I fully disagree" to 7 = "I fully agree"

Organizational Context

Organizational context comprises **formalization** (form), **centralization** (cent), **opportunity screening** (opp_screen) and **connectedness** (connect). All constructs are adapted from Jaworski and Kohli (1993).

As elaborated earlier, centralization refers to the way in which decisions are made and where they are concentrated within an organization, as well as the locus of decision-making (Aiken & Hage, 1968, p. 928; Auh & Menguc, 2007, p. 1025; Damanpour, 1991, p. 589; Jaworski & Kohli, 1993, p. 56). On the other hand, formalization – as defined in Chapter 2.3.3.5 – indicates the level of rules, determining processes, standards, procedures, information exchange and decisions (Jaworski & Kohli, 1993, p. 56). Connectedness covers for the general willingness of co-workers to help, interact and collaborate with each other as well as other departments (Jaworski & Kohli, 1993, p. 56). Opportunity screening is defined as the regular scanning, evaluation, and discussion of customer and market insights and trends, which is tantamount to the "intelligence generation and dissemination" item from Jaworski and Kohli (1993) (Hüsig et al., 2005, p. 861; Jaworski & Kohli, 1993, p. 56; Zaltman et al., 1973, p. 62).

Two items from formalization (form6_re and form10_re) had to be removed due to poor reliability measures. The mean of the remaining items lies between 3.55 and 4.95. The discriminating power of all items is above 0.5, and thus the items represent the construct. The reliability measure Cronbach Alpha lies above 0.7 for all constructs. Details can be found in Table 21.

	Label	Independent variables Text	M	SD	DP	α
Organizational context		**Formalization**	4.92			0.732
	form1_re	I feel that I am my own boss in most matters. (reverse coded)	5.26	1.41	0.58	
	form3_re	How things are done around here is left up to the person doing the work. (reverse coded)	4.58	1.40	0.64	
	~~form6~~	~~Rules and procedures occupy a central place in the organizational unit.~~	~~3.02~~	~~1.39~~	~~0.42~~	
	~~form10~~	~~Whatever situation arises, written procedures are available for dealing with it.~~	~~3.78~~	~~1.79~~	~~0.42~~	
		Centralization	3.554			0.909
	cent1	A person who wants to make his own decision would be quickly discouraged here	3.62	1.78	0.64	
	cent2	Even small matters have to be referred to someone higher up for a final answer.	3.89	1.92	0.85	
	cent3	I have to ask my boss before I do almost anything.	3.27	1.87	0.93	
	cent4	Any decision I make has to have my boss' approval.	3.42	1.89	0.94	
		Interdepartmental connectedness	4.95			0.751
	connect1	In this business unit, it is easy to talk with virtually anyone you need to, regardless of rank or position.	4.63	1.62	0.63	
	connect2	There is ample opportunity for informal "hall talk" among individuals from different departments in this business unit.	4.22	1.67	0.58	
	connect3	In this business unit, employees from different departments feel comfortable calling each other when the need arises.	5.10	1.46	0.71	
	connect4	People around here are quite accessible to those in other departments.	5.09	1.27	0.66	
		Opportunity screening	4.367			0.765
	opp_screen1	We have interdepartmental meetings at least once a quarter to discuss market trends and developments.	3.41	2.10	0.51	
	opp_screen2	Marketing personnel in our business unit spend time discussing customers' future needs with other functional departments. // In our unit, we spend time discussing future technological possibilities and requirements with other business units.	4.43	1.76	0.68	
	opp_screen3	Our department periodically circulates documents (e.g., reports, newsletters) that provide information on our customers.	4.43	1.85	0.71	
	opp_screen4	When something important happens to a major customer or market, the whole business unit knows about it in a short period.	4.29	1.74	0.76	

Table 21: Item- and Construct Characteristics of Organizational Context Variables

Notes:
M = mean, SD = standard deviation, DP = discriminating power, α = Cronbach alpha
n = 389 (missings possible)
Answer dimension: 1 = “I fully disagree” to 7 = “I fully agree”

External Environment

Three environmental constructs were used in the survey, namely **technology turbulence** (turb_tec) **market turbulence** (turb_mark) **and competitive intensity** (comp). Technology turbulence aims to cover technological changes and advancements (Zheng et al., 2005, p. 47), while market turbulence grasps the degree of changes regarding customer preferences as well as market uncertainty (Jaworski & Kohli, 1993, p. 57; Santos-Vijande & Álvarez-González, 2007, p. 519). Competitive intensity covers the situation regarding overall competition. When competition intensifies, confidence and certainties fade, forcing companies to act differently (Auh & Menguc, 2005, p. 1654).

All items were adapted from Jaworski and Kohli (1993) and have frequently been used in renowned journal articles (e.g., Baker & Sinkula, 2007; Calantone, Garcia, & Dröge, 2003; Jansen et al., 2006; Y. Wei, O’Neill, Lee, & Zhou, 2012) and thus pose well-established measures. One item from competitive intensity had to be removed due to poor reliability measure and discriminating power (comp3). The mean of the rest of the items lies between 4.13 and 5.74. The discriminating power of all items is above 0.5 or very close to it; thus, the items represent the according construct. The reliability measure Cronbach Alpha lies above 0.7 for all constructs, displaying good reliability. Details are shown in Table 22.

		Independent variables				
	Label	Text	M	SD	DP	α
External environment		**Technology turbulence**	5.181			0.749
	turb_tec1	The technologies in our industry are changing rapidly.	4.98	1.43	0.68	
	turb_tec2	Technological changes provide big opportunities in our industry.	5.65	1.15	0.6	
	turb_tec3	A large number of new product ideas have been made possible through technical breakthroughs in our industry.	4.87	1.48	0.62	
	turb_tec4_re	Major technological changes in our industry are rather scarce. (reverse coded)	4.69	1.67	0.62	
		Market turbulence	4.571			0.703
	turb_mark1	In our kind of business, customers' product preferences change quite a bit over time.	4.57	1.45	0.64	
	turb_mark2	Our customers tend to look for new products all the time.	5.02	1.47	0.56	
	turb_mark3	We are witnessing demand for our products and services from customers who never bought them before.	4.13	1.56	0.66	
	turb_mark4	New customers tend to have product-related needs that are different from those of our existing customers.	4.84	1.57	0.48	
		Competitive intensity	5.752			0.707
	comp1	Competition in our industry is cutthroat.	5.72	1.16	0.71	
	~~comp3~~	~~Anything that one competitor can offer, others can match readily.~~	~~4.04~~	~~1.36~~	~~0.15~~	
	comp4	Price competition is a hallmark of our industry.	5.74	1.30	0.59	
	comp6_re	Our competitors are relatively weak. (reverse coded)	5.72	1.26	0.58	

Table 22: Item- and Construct Characteristics of External Environment Variables

Notes:
M = mean, SD = standard deviation, DP = discriminating power, α = Cronbach alpha
n = 389 (missings possible)
Answer dimension: 1 = "I fully disagree" to 7 = "I fully agree"

Control Variables

Derived from the qualitative study, several control variables were added, such as **process satisfaction** (sat_pro), **unit affiliation** (unit), **age** (age), **work tenure** (dur_wo) and **managerial responsibility** (resp). Table 23 shows the details of the variables being controlled for.

		Independent Variables				
	Itemlabel	Itemtext	M	SD	DP	α
Control variables		**Process satisfaction**	4.143			0.807
	sat_pro1	Our activities preceding the start of development are well organised.	4.31	1.56	0.75	
	sat_pro2	I am satisfied with the results of our activities preceding the start of development.	3.99	1.50	0.75	
		Unit				
	unit	unit [1-6] [Mobility Systems, Software Systems, Consumer Goods & Building Technology, Materials & Sensors, Components & Simulation, Manufacturing Technologies]	3.74	1.84	-	
		Age				
	age	Age [free numerical field]	38.09	36		
		Work tenure				
	dur_wo	How long have you been working for the company? [free numerical field]	10.20	8		
		Managerial responsibility				
	resp	Do you possess managerial responsibility? [yes, no]	0.14	0		

Table 23: Item- and Construct Characteristics of Control Variables

Notes:
M = mean, SD = standard deviation, DP = discriminating power, α = Cronbach alpha
n = 389 (missings possible)
Answer dimension: 1 = "I fully disagree" to 7 = "I fully agree" unless stated otherwise in square parenthesis

Furthermore, two items were retrieved to further illuminate the context of innovation field application. In order to grasp the prioritization of intended innovation field applications, a **ranking variable** (inno_rank) was constructed. Respondents were asked *for which type of application they intend to apply innovation fields the most* and they were requested to rank pre-determined applications from 1 to 10. Furthermore, the **frequency of usage regarding the online information system for innovation management** (data) was added to gain insights into the actual application of innovation fields in the system at the corporate R&D division.

5.4 Data Analysis

After elaborating on the constructs used in the quantitative study, this section will elaborate on data imputation and premises for multiple linear regressions.

Imputation

Due to the survey setup including non-forced answers in the survey design, the data set holds missings in some variables. Normally, these questionnaires are excluded from the analysis by list-wise deletion. In this case, this would have resulted in a significant reduction in the usable number of questionnaires by over 30%. Thus, it was decided to use an **imputation method** to replace the missings. There are several options to fill in missings, such as (1) complete case analysis, (2) ad-hoc methods or (3) multiple imputations. Complete case analyses are the simplest option, ensuring no missing values through list-wise deletion of incomplete data sets. Ad-hoc methods comprise filling in missing values by using mean imputation (replacement through average observed values), excluding variables with a high number of missing values or using the last-observed value to fill in for replacement. These ad-hoc measures are critiqued and not recommended since they either cause bias or exclude important factors. Thus, a multiple imputation method shows to be a more reliable method, not inducing bias (Horton & Kleinman, 2007, p. 80).

There are two main methods: *joint modeling* (JM) and *fully conditional specifications* (FCS), which is also known as *multivariate imputation by chained equations* (MICE) (Horton & Lipsitz, 2001, p. 248; van Buuren & Groothuis-Oudshoorn, 2011, p. 1). The method of MICE is preferred to JM in the case of "no suitable multivariate distribution" (van Buuren & Groothuis-Oudshoorn, 2011, p. 2). MICE works by "specif[ying] the multivariate imputation model on a variable-by-variable basis by a set of conditional densities, one for each incomplete variable" (van Buuren & Groothuis-Oudshoorn, 2011, p. 2). The MICE approach has also been used in a renowned journal in management science (Jensen, 2008; van Buuren & Groothuis-Oudshoorn, 2011) and thus proves to be an adequate approach for filling in missing data points. The default method for continuous missing variables is so-called *predictive mean matching (PMM)*, which is an extension to the regression imputation method. The regression imputation method performs a regression with the available data. With the help of the regression coefficients, missing values are predicted. Thus, all filled-in data lies on the regression curve. When using predictive mean matching, after performing a regression imputation, in all complete data sets, values are searched for that are close to the imputed value. Third, the imputed values are replaced by the observed real values from the complete data sets. With this approach, it is secured that the imputed value is taken from "a set of observed values whose predicted values are closest to the predicted value from a specified regression model" (Göthlich, 2009, p. 125; Horton & Kleinman, 2007, p. 81; R. J. A. Little, 1988, p. 291).

The MICE approach assumes that data are missing at random (MAR) as opposed to data missing completely at random (MCAR) (Horton & Kleinman, 2007, p. 80). MCAR means that "the failure to observe a value does not depend on any data, either observed or missing"; thus, the observed and missing values of one variable are entirely unrelated to any other variable in the data (Baraldi & Enders, 2013, p. 637; Ibrahim, Chen, Lipsitz, & Herring, 2005, p. 333). On the other hand, data is MAR when there is actually a relationship between observed and missing data. "[…] the conditional probability of missingness may depend on any observed data. Moreover, the unconditional probability of missingness may, in fact, depend on unobserved data" (Ibrahim et al., 2005, p. 333).

To prove that data is missing at random, the missing patterns were visualized, and margin plots for the variables with the most missings were performed with the VIM package in R (Kowarik & Templ, 2016). In the case of data that is MAR, the distribution of observed values and the distribution of missing data points is supposed to be non-identical. The following figure presents an exemplary margin plot showing that data is MAR since the red and blue box-plots are not similar. Appendix A08 shows other margin plots from the data and missing data patterns in the data set.

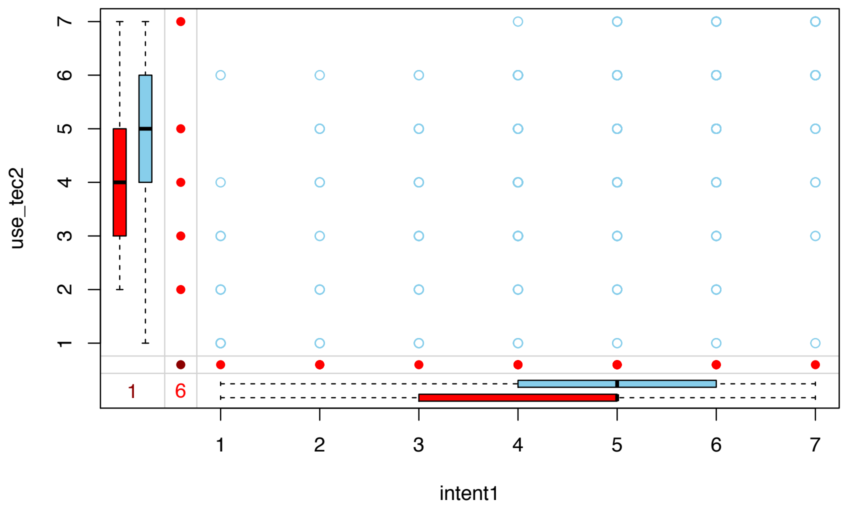


Figure 38: Analysis of Missing Data

Notes:
Source: performed with R package VIM

The imputation was done in R with the package MICE (van Buuren, 2017). For each variable with missing values, the imputation was performed with either PMM for categorical and continuous variables or a logistic regression for binary variables (van Buuren & Groothuis-Oudshoorn, 2011, p. 12). A single imputation was performed, setting the number of imputation runs to one and the imputed data[26] was extracted from the data set with the complete function in R (van Buuren & Groothuis-Oudshoorn, 2011, p. 12).

One important step after the imputation is a plausibility check of the imputed data (van Buuren & Groothuis-Oudshoorn, 2011, p. 11) and distribution check of the data before and after imputation (van Buuren & Groothuis-

[26] A maximum of 60 data points was predicted.

Oudshoorn, 2011, p. 12). The statistical distribution of the variables was controlled for, and no significant changes could be detected in the distribution measures. The comparison between the imputed and raw data distribution measures can be found in Appendix A10. After imputing the missing values for single items, construct scores were created by adding up the individual values of items of the corresponding construct and calculating the mean.

Multiple Linear Regression Premises

A **multiple linear regression** was performed for each of the nine dependent variables. Two different exploratory regression types were performed: step-wise linear regression with Akaikes Information Criterion (AIC) fitting and step-wise polynomial regression with quadratic terms and AIC fitting (Bozdogan, 1987, p. 368). **Polynomial regressions** were performed due to the assumption that relationships between dependent and independent variables are not linear, but rather curvilinear. Polynomial regression models reveal and predict convex or concave relationships rather than simple linear relationships (Bajpai, 2010, p. 522; UCLA: Statistical Consulting Group, 2017).

Polynomial models are preferred in cases with a better fit, meaning a substantially better fit of the quadratic model than the linear model. The better fit is shown through an increase in explained variance (r^2), although it must be considered with reason in light of theoretical assumptions. Adding a quadratic term to a linear regression will result in a higher r^2. It has to be checked that the increase of explained variance is greater than coincidentally expected (Bajpai, 2010, p. 527). The same rules apply for AIC fitting, providing very good model fit, but not necessarily the best fit. The step-wise regression is a data-driven method for that gradually adds terms to the model that significantly improve the model fit (Luhmann, 2015, p. 231). Since this data-driven method is an exploratory method, the model choice was made with caution and reason in order to choose the best-fitting model within the context. For each dependent variable, both the quadratic and the linear regression model were compared regarding explained variance and overall model fit. Upon these comparisons, the model with the quadratic or linear terms was chosen for interpretation. Some models showed significant quadratic terms, but not the corresponding linear term. For these cases, a likelihood-ratio test was performed for the full and reduced model. The comparison between the quadratic and linear models can be found in Appendix A11.

Some requirements and model premises have to be met when performing linear regressions. These also apply for polynomial regressions, which are a type of linear regression (Bajpai, 2010, p. 522). First, the correct model specification needs to be ensured. This entails the choice of all relevant variables including the consideration of interaction terms or curvilinear relationships to ensure best model fit (Luhmann, 2015, p. 233). Second, homoscedasticity must be given, defined as “extent to which the data values for the dependent and independent variables have equal variances” (Saunders et al., 2009, p. 462). Third, outliers must be checked, since they might influence or even distort the estimates (Luhmann, 2015, p. 233). Fourth, the absence of multicollinearity must be analyzed. When the independent variables do not correlate with each other, multicollinearity is not given. This can be examined with the so-called variance inflation factor (Saunders et al., 2009, p. 463). Fifth, normal distribution of residuals needs to be given, which can be analyzed either visually or through analyzing sample sizes above forty questionnaires (Luhmann, 2015, p. 234). The following table explains, the analysis method performed for the model premises and the results of the underlying regression models. All model premises were checked for each regression model.

Model premises	Analysis method	Result
Correct model specification	• Cautious choice of final model, examination of curvilinear relationships • Visual analysis of residuals vs. fitted diagram	• Depending on context, best-fitting model was taken with or without higher-order terms • Residual vs. fitted scatter plot shows unsystematic distribution of data points and Lowess-line parallel to x-axis
Homoscedasticity	• Visual analysis of Scale-Location diagram. Fitted values are displayed on the x-axis and standardized residuals on the y-axis.	• Homoscedasticity is given due to unsystematic distribution of scatter plot
Outliers	• Initially, each item was checked for outliers and questionnaires with a large number of missings were excluded from the analysis • Visual analysis of Residuals vs. Leverage plot and Cook's distance measure.	• Check for outliers and missings over 10% and exclusion of questionnaires • No influential outliers detected due to no data points in scatter plot outside of cook's distance measure
Multicollinearity	• Analysis of variance inflation factor (VIF) close to 1 and < 10	• VIF is close to 1 (<2.5) for all linear regression models • For polynomial regressions, higher-order terms show a VIF <10. In these cases, multicollinearity is not an issue since the effects are not independent and the higher-order terms correlate with the lower-order terms
Normal distribution of residuals	• Sample size >40 • Visual analysis of Normal-Q-Q-plot. The x-axis shows expected quantiles, y-axis actual observed quantiles. Normal distribution is shown through a diagonal in plot	• Sample size >40 (n=389), therefore normal distribution expected • Diagonal distribution in Q-Q-plot throughout all models

Table 24: Model Premises for Linear Regression

Notes:
Source: Backhaus, Erichson, Plinke, & Weiber, 2011, p. 80ff.; Luhmann, 2015, p. 233ff.; Neter, Wasserman, & Kutner, 1985

All scatter and residual plots for each of the models can be found in Appendix A11.

Quadratic terms can be best interpreted visually and in conjunction with their linear terms. To support the visualization, the R-package LinReginteractive (Meermeyer, 2014) was used to show the concave or convex gradient of the curve. For models with quadratic terms, the graph will be included for better understanding and interpretation of the effect. Unstandardized estimates are reported, reflecting a more common reporting method in an increasing number of journals (Ethiraj, Gambardella, & Helfat, 2017). Additionally, all items in the questionnaire are Likert scales, making the regression coefficients comparable.

The explained variance from all the models ranges between 9.0% and 15.8%, with seemingly low numbers. According to Kleiningham et al. (2008), questions according to attitude and behavior can only explain 0-20% of the variance of the actual behavior and at least 80% have to be explained differently (Kleinigham, Aksoy, Cooil, & Andreassen, 2008, p. 54), which makes the values of the explained variance acceptable.

To analyze the results, different statistical methods were used, which were performed with Excel, SPSS, and R.

5.5 Biases

The sample was tested for the most prevalent biases, namely the non-response bias and common-method bias.

Non-Response Bias

In accordance to Armstrong and Overton (1997), it can be assumed that late responses equal non-respondent answers (Armstrong & Overton, 1977). By comparing the responses from early and late respondents, non-response bias can be tested, as performed in many recent studies (Durmusoglu & Barczak, 2011; Jackson, Yi, & Park, 2013; Nag et al., 2007).

In order to check for non-response bias, the sample was divided into three sub-sets (n1, n2, n3) according to the date when the survey was answered, resulting in an early and late response sub-set (n1 and n3). The sub-sets were compared with an independent sample t-test in variables of interest, showing no differences in the mean responses of the tested variables. Thus, it can be concluded that non-response-bias is not prevalent. The results can be viewed in Appendix A09.

Common-Method Bias

Common-method bias is a serious threat to study designs if dependent and independent variables come from a single source. This can affect reliability measures and the validity of the results and thus needs to be checked. There are several ex-ante and ex-post tools used in this survey to ensure that common-method bias is not prevalent.

Several ex-ante precautions were taken. First, the study design is a mixed-methods approach using qualitative information through interviews besides the quantitative survey (Craighead, Ketchen, Dunn, & Hult, 2011, p. 583). Second, anonymity was guaranteed to respondents, which is an instrument to overcome social desirability effects that can cause common-method bias (Podsakoff, MacKenzie, & Podsakoff, 2012, p. 562). Third, the survey was pre-tested to gain feedback regarding the clarity of questions, which is also a procedural measure to reduce the presence of common-method bias (Eichhorn, 2014, p. 2).

Ex-post, Harman's single-factor test is a predictor of the existence of common-method bias, in which an exploratory factor analysis is performed. Specifically, an unrotated factor analysis with the principal component method that including all variables is performed (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). If common-method bias is present, one single common latent factor accounts for more than 50% of the variance (Eichhorn, 2014, p. 4; Harman, 1960). One factor was created with all dependent and independent variables performing an unrotated factor analysis with the principle component method, and this factor only accounts for 19% of the variance, being below the threshold of 50%. Furthermore, a scree plot showed eleven distinct factors with eigenvalue above 1 (Kaiser criterion). Therefore, common-method bias is not a major issue here (Revelle, 2017).

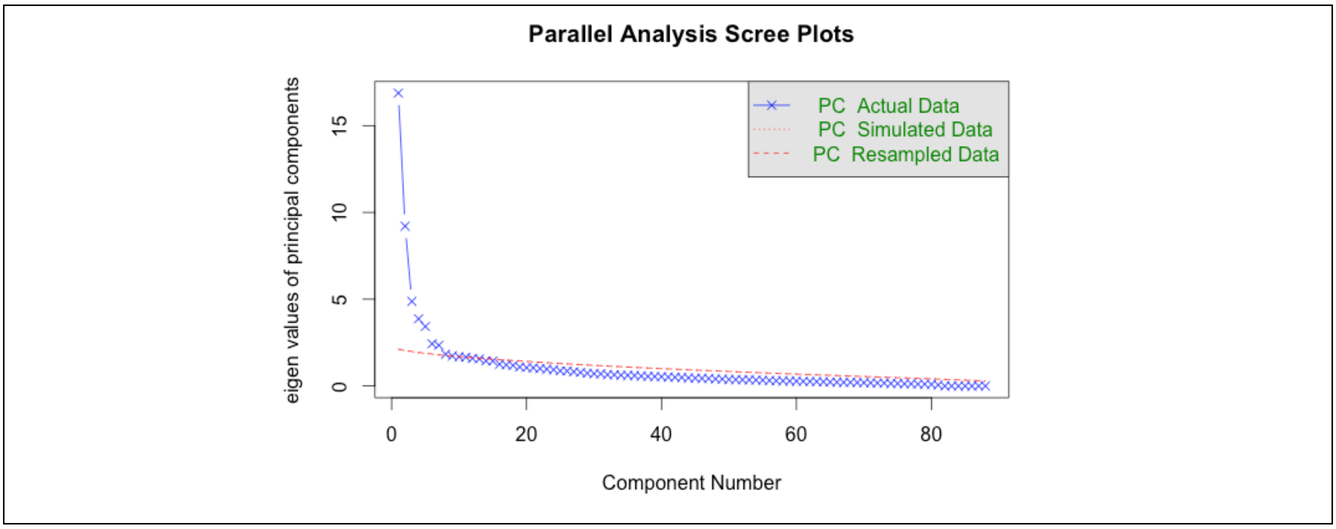


Figure 39: Parallel Analysis Scree Plot

Notes
Source: performed with R-package psych

5.6 Results of Quantitative Study

The following chapter presents the findings of the quantitative survey. Table 25 shows the correlation matrix. To avoid problems with multicollinearity, the dependent variables were entered in separate models and additionally VIF factors were checked (Frishammar & Ake Hörte, 2005, p. 258; Katila & Ahuja, 2002, p. 1188).

Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	General intention to use innovation fields	1	0.61***	0.59***	0.66***	0.52***	0.4***	0.6***	0.62***	0.48***	0.18*	0.15	0.17'	0.00	0.15	-0.11	0.15	0.05	0.03	0.06	0.14
2	Application of innovation fields for strategic purposes	0.61***	1	0.63***	0.69***	0.52***	0.38***	0.65***	0.61***	0.48***	0.16	0.17	0.15	0.01	0.17.	-0.08	0.17	0.09	0.00	0.06	0.11
3	Application of innovation fields for ideation	0.59***	0.63***	1	0.63***	0.67***	0.55***	0.68***	0.71***	0.64***	0.11	0.08	0.10	0.08	0.06	0.06	0.12	0.06	0.06	0.06	-0.02
4	Application of innovation fields for lifting synergies	0.66***	0.69***	0.63***	1	0.64***	0.49***	0.7***	0.7***	0.62***	0.12	0.13	0.20*	-0.05	0.12	-0.04	0.14	0.07	0.07	0.13	0.09
5	Application of innovation fields for technology intelligence	0.52***	0.62***	0.67***	0.64***	1	0.57***	0.67***	0.69***	0.67***	0.10	0.18*	0.20*	0.02	0.13	-0.04	0.11	0.09	0.04	0.05	-0.03
6	Application of innovation fields for portfolio extension	0.4***	0.38***	0.55***	0.49***	0.57***	1	0.57***	0.63***	0.67***	0.04	0.13	0.15	-0.02	0.03	0.00	0.15	0.07	0.08	0.12	-0.10
7	Perceived usefulness of innovation fields	0.6***	0.65***	0.68***	0.7***	0.67***	0.57***	1	0.8***	0.73***	0.10	0.15	0.20*	-0.03	0.07	-0.01	0.13	0.07	0.11	0.07	-0.03
8	Innovation fields enhancing performance	0.62***	0.61***	0.71***	0.7***	0.69***	0.63***	0.8***	1	0.78***	0.11	0.14	0.17'	0.00	0.08	-0.05	0.16	0.09	0.07	0.09	-0.03
9	Innovation fields enhancing innovativeness	0.48***	0.48***	0.64***	0.62***	0.67***	0.67***	0.73***	0.78***	1	0.06	0.07	0.14	-0.03	0.04	0.02	0.13	0.03	0.14	0.11	-0.03
10	Customer orientation	0.18***	0.16**	0.11*	0.12*	0.10*	0.04	0.10*	0.11*	0.06	1	0.35***	0.31***	0.10	0.18*	-0.06	0.19.	0.31***	0.12	0.12	0.15
11	Technology orientation	0.15**	0.17**	0.08'	0.13*	0.18**	0.13*	0.15**	0.14*	0.07	0.35***	1	0.52***	0.02	0.34***	-0.29***	0.28***	0.37***	0.16	0.25***	0.09
12	Exploration	0.17**	0.15**	0.10*	0.20**	0.20**	0.15**	0.20**	0.17**	0.14*	0.31***	0.52***	1	-0.26***	0.34***	-0.35***	0.37***	0.53***	0.32***	0.37***	0.07
13	Exploitation	0.00	0.01	0.08	-0.05	0.02	-0.02	-0.03	0.00	-0.03	0.1.	0.02	-0.26***	1	-0.01	0.11	-0.04	-0.02	-0.09	-0.22**	-0.04
14	Formalization	0.15**	0.17**	0.06	0.12*	0.13*	0.03	0.07	0.08'	0.04	0.18***	0.34***	0.34***	-0.01	1	-0.54***	0.19.	0.26***	0.07	0.07	0.03
15	Centralization	-0.11*	-0.08	0.06	-0.04	-0.04	0.00	-0.01	-0.05	0.02	-0.06	-0.29***	-0.35***	0.11*	-0.54***	1	-0.15	-0.28***	-0.01	-0.06	-0.08
16	Connectedness	0.15**	0.17**	0.12*	0.14*	0.11*	0.15*	0.13*	0.16**	0.13*	0.19***	0.28***	0.37***	-0.04	0.19**	-0.15***	1	0.35***	0.15	0.19*	0.01
17	Opportunity screening	0.05	0.09.	0.06	0.07	0.09.	0.07	0.07	0.09.	0.03	0.31***	0.37***	0.53***	-0.02	0.26***	-0.28***	0.35***	1	0.22**	0.29***	0.11
18	Market turbulence	0.03	0.00	0.06	0.07	0.04	0.08	0.11*	0.07	0.14*	0.12*	0.16**	0.32***	-0.09.	0.07	-0.01	0.15***	0.22***	1	0.51***	0.10
19	Technology turbulence	0.06	0.06	0.06	0.13*	0.05	0.12*	0.07	0.09.	0.11*	0.12*	0.25***	0.37***	-0.22**	0.07	-0.06	0.19***	0.29***	0.51***	1	0.26***
20	Competitive intensity	0.14*	0.11*	-0.02	0.09.	-0.03	-0.10'	-0.03	-0.03	-0.03	0.15***	0.09.	0.07	-0.04	0.03	-0.08	0.01	0.11.	0.10.	0.26***	1

Table 25: Correlation Matrix

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

In the following, the regression models and their findings are presented. The models are reported in the order of the likelihood of the application, indicated by Figure 40 below, starting with the general intention to use innovation fields and other models for intended innovation field applications, followed by models for overall perceived usefulness, performance, and innovativeness.

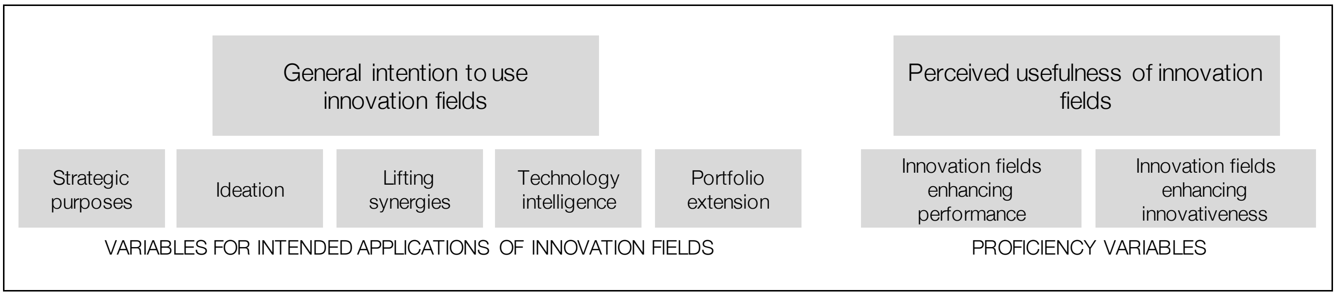


Figure 40: Overview of Model Reporting Structure

Notes:
Source: own representation

For each model, relevant descriptive variables are presented, if applicable. Subsequently, it is argued whether the quadratic or linear model is chosen, followed by the display and explanation of the regression results. Interesting or surprising findings are discussed. First, the control variables were added to the model, followed by the controls and main effects taken together. An overview of the models can be found in Appendix A11.

5.6.1 Results for Intended Innovation Field Applications

Respondents were asked to rank the intended innovation field applications, showing the likelihood of each intended application being employed. This item represents the actual number of respondents using innovation fields for a certain application. Below, Table 26 shows an overview of the ranking.

Ranking intended application for innovation fields	Main application (Rank 1)	Application (Rank 1-5)	No application
Strategic purposes	27.2%	77.1%	22.9%
Ideation	10.5%	68.8%	31.4%
Lifting synergies	9.8%	74.3%	25.7%
Technology intelligence	5.9%	51.9%	48.1%
Portfolio extension	1.0%	37.0%	63.0%

Table 26: Overview of Ranked Innovation Field Applications

Notes:
Source: own representation
Answer dimension: ranking
Missings possible

The application of innovation fields for strategic purposes is the most important intended innovation field application with almost one-third of respondents ranking it as the main application. Although the intended usage of innovation fields for ideation is listed as the second-most important application, only 10% of respondents classify it as the main application. Since a major part of the front-end of innovation evolves around ideation and idea management, this is an interesting fact that will be further elaborated in the discussion chapter. Two-thirds of respondents rank intended application of innovation fields for ideation as an intended type of application (rank 1-5). Lifting synergies is the third-ranked intended main application, with 9.8% of respondents placing it first. Technology intelligence and portfolio extension are ranked fourth and fifth with only 5.9% and 1% of respondents classifying it as a main intended application. Only half of the respondents state applying innovation fields for technology intelligence, while only one-third of respondents claim to apply it for portfolio extension, indicating that those types of applications are more specialized.

5.6.1.1 General Intention to Use Innovation Fields

First, the general application of innovation fields will be captured through analyzing the usage frequency of the internal online information system for innovation management, followed by the presentation of influencing factors of the intended general application of innovation fields.

Innovation fields are stored in an internal online information system for innovation management. Access is granted to all R&D division employees and selected internal customers (business divisions). 72.2% claim to use the online information system regularly (daily to once a month) and 19.5% use the online information system rarely (once a quarter to once a year). Only 6.7% of respondents do not use the online information system at all. Besides the storage of innovation fields, the online information system (as described in Chapter 3.4.2) also stores ideas and projects along the stage-gate process. From the numbers, it can be concluded that the R&D employees know and use the online information system frequently, which is an essential prerequisite for the overall application of innovation fields.

There is a dedicated module in the online information system, displaying innovation fields. The frequency of usage for this specific module is much lower than the overall usage of the online information system: 26.5% of respondents show regular usage, while 49.9% only rarely use the innovation field module in the online information system and 19.8% have never used it. Two reasons can explain the differences between the general usage of the online information system and the usage of the innovation field module. First, idea and project management are daily activities, in which action is needed on a regular basis. With innovation fields being more long-term oriented, there may be less need for the regular use of the online information system. Secondly, the large proportion of non-users (19.8%) can be explained through the short time of implementation of innovation fields. At the time of the survey, the innovation fields had been introduced for approximately twelve months, showing that the dissemination of this instrument was not completed. Nevertheless, within twelve months, 76.3% of respondents have used the module at least once.

For the regression model, the polynomial model was chosen due to the better overall model fit.

Controls & quadratic main effects					
Dependent variable: general intention to use innovation fields					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-6.360	2.265	-2.808	0.005	**
Customer orientation	0.978	0.399	2.450	0.015	*
Customer orientation^2	-0.085	0.041	-2.103	0.036	*
Formalization	-0.098	0.059	1.651	0.100	.
Opportunity screening	0.093	0.261	0.357	0.722	
Opportunity screening^2	-0.026	0.031	-0.852	0.395	
Connectedness	-0.148	0.387	-0.382	0.703	
Connectedness^2	0.034	0.043	0.784	0.433	
Competitive intensity	2.540	0.733	3.467	0.001	***
Competitive intensity^2	-0.220	0.068	-3.248	0.001	**
Process satisfaction	0.196	0.055	3.576	0.000	***
F-statistic: 6.881 on 10 and 369 DF	p-value: 6.971e-10				
Residual standard error: 1.339 on 369 degrees of freedom					
Multiple R^2: 0.1572	**Adjusted R^2: 0.1343**				

Table 27: Regression Model for General Intention to Use Innovation Fields

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

For the general intention to use innovation fields, significant effects for customer orientation, formalization, competitive intensity, and the control variable process satisfaction could be detected. The regression model shows inverse U-shaped-relationships for customer orientation and competitive intensity, a significant negative linear effect for formalization and a positive effect for the control variable of process satisfaction. The model additionally contains quadratic terms for connectedness and opportunity screening, both of which are not significant. The complete model is highly significant (p-value 0.000), and the independent variables explain 13.43% of the variance of the dependent variable.

Figure 41 shows the two U-shaped relationships in the underlying model: customer orientation and competitive intensity. These terms can only be interpreted visually and together with their linear terms.

Competitive intensity shows the strongest effect in the model with the estimates 2.54 and -0.22 for the quadratic term. The graphical display shows a concave relationship: up to 5.74, competitive intensity shows a positive impact on the intended usage of innovation fields. After this point, the effect is reversed, meaning that in a highly competitive environment, the intention to use innovation fields decreases. This finding is in line with results from Tsai and Yang (2013) regarding competitive intensity and the relationship to innovativeness, stating that "radical competitor attacks" will nullify innovativeness (Tsai & Yang, 2013, p. 1287). In the case of general intention to use innovation fields, the course of immediate action might require diverging from innovation activities and change direction towards imitation (Baker & Sinkula, 2007, p. 326).

Furthermore, a significant effect could be detected with the quadratic term of customer orientation. The graph shows a concave course, showing a positive relationship up to 5.77, then turning into a negative relationship. This relationship supports the qualitative study, indicating that a very high customer orientation has a reverse effect on the intended usage of innovation fields. In Baker and Sinkula (2007), it was shown that market orientation (in this case, tantamount with customer orientation) facilitates the balancing between exploitation and exploration (Baker & Sinkula, 2007, p. 329). Thus, for employees declaring to be customer-oriented, innovation fields are a means for reaching ambidexterity and they are perceived as a supporting mechanism. In a setting with very high customer orientation, customers will articulate their needs and requirements precisely, leading to an equal amount of guidance as with innovation fields, thus making them obsolete.

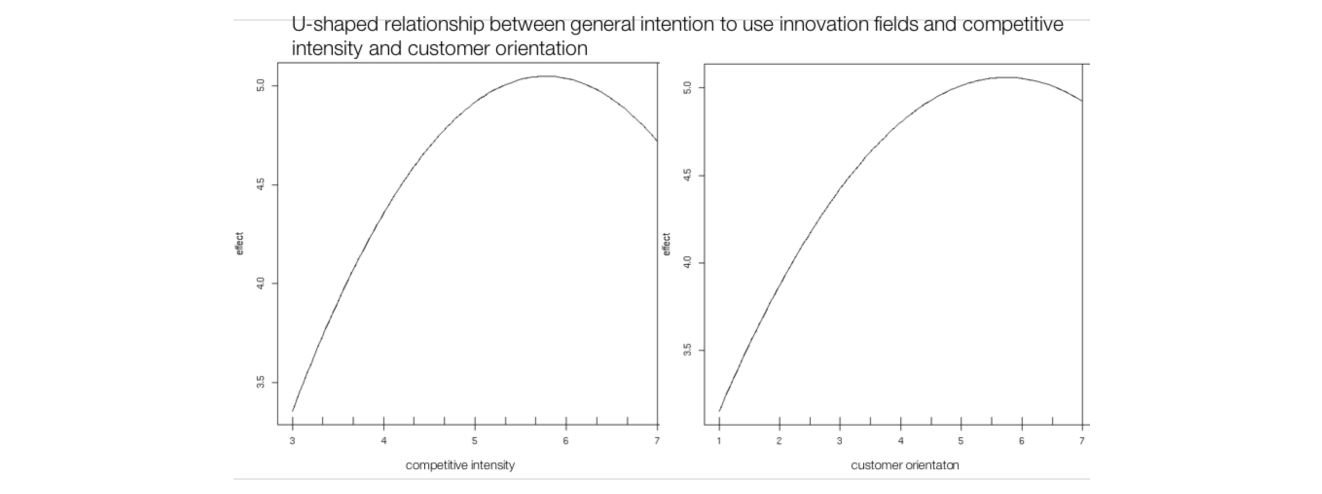


Figure 41: Curvilinear Effects for General Intention to Use Innovation Fields

Notes:
Source: performed with R-package LinRegInteractive
Effects displayed from left to right: competitive intensity, customer orientation

The model shows that formalization has a weak negative linear effect (-0.10) on the general intention to use innovation fields. The more formalized the climate in the department, the less likely respondents are inclined to use innovation fields. This finding is in line with the results from the qualitative study. Notably, with a high formalization, innovation fields are not perceived as a supportive guiding mechanism but rather as a means to reduce autonomy.

Process satisfaction has a significant positive impact on the application of innovation fields throughout all models. Since innovation fields are an instrument within the existing NPD process, process satisfaction is an important indicator for the likelihood of engaging with adaptions and adjustments to the established process and needs to be taken into account when implementing or introducing new instruments. The general intention to use innovation fields is thus influenced by the overall satisfaction with the established NPD process, linking to the perceived quality and usefulness of the processes in place (Hüsig et al., 2005, p. 865). Figure 42 summarizes the regression results for the general intention to use innovation fields.

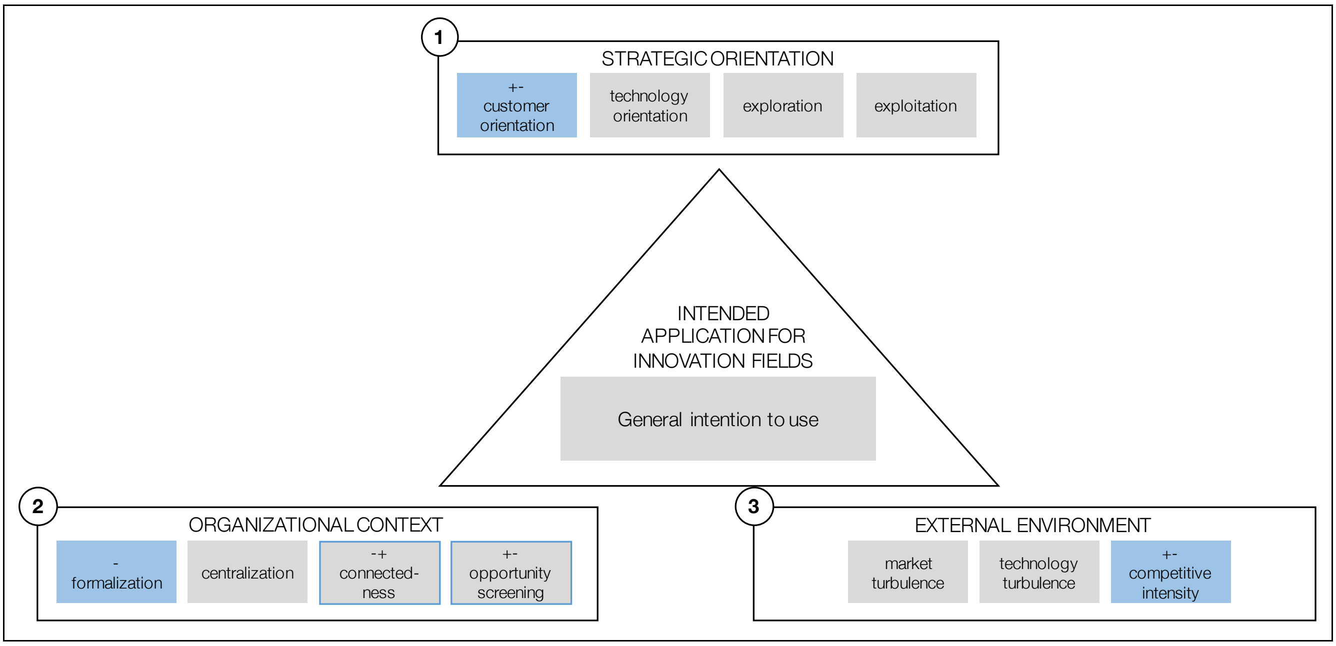


Figure 42: Summary of Results for General Intention to Use Innovation Fields

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.1.2 Intended Application of Innovation Fields for Strategic Purposes

The intended application of innovation fields for strategic purposes is the highest-ranked intended type of application, with 27.2% of respondents selecting it as the main intended application (rank 1) and 77.1% of respondents mentioning it as potential but not the main application (rank 2-9). Around one-fifth (22.9%) did not select it as a potential application. Table 28 lists the detailed ranking for the intended application of innovation fields for strategic purposes.

Application of innovation fields for strategic purposes	No. of responses	%
Main application (Rank 1)	106	27.2%
Rank 2	70	18.0%
Rank 3	47	12.1%
Rank 4	19	4.9%
Rank 5	21	5.4%
Rank 6	15	3.9%
Rank 7	12	3.1%
Rank 8	3	0.8%
Rank 9	7	1.8%
Rank 10	0	0.0%
No application	89	22.9%

Table 28: Ranking of Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: own representation
Answer dimensions ranking from one to ten

For the model intended use of innovation fields for strategic purposes, the quadratic regression model was chosen due to the better overall model fit.

The model shows significant effects for customer orientation, formalization, connectedness, competitive intensity, and the control variables process satisfaction as well as managerial responsibility.

The complete model is highly significant (p-value: 0.000), and the independent variables explain 10.6% of the variance of the dependent variable.

Controls & quadratic main effects					
Dependent variable: application of innovation fields for strategic purposes					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-0.484	1.837	-0.263	0.793	
Customer orientation	0.625	0.317	1.971	0.050	*
Customer orientation^2	-0.056	0.032	-1.746	0.082	.
Formalization	-0.089	0.048	1.867	0.063	.
Connectedness	-0.499	0.313	-1.594	0.112	
Connectedness^2	0.071	0.034	2.056	0.041	*
Competitive intensity	1.538	0.595	2.584	0.010	*
Competitive intensity^2	-0.134	0.055	-2.428	0.016	*
Process satisfaction	0.096	0.044	2.172	0.031	*
Responsibility	-0.385	0.167	-2.305	0.022	*
F-statistic: 5.993 on 9 and 370 DF	p-value: 7.554e-08				
Residual standard error: 1.09 on 370 degrees of freedom					
Multiple R^2: 0.1272	**Adjusted R^2: 0.106**				

Table 29: Regression Model for Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Three quadratic terms were found to be significant in the underlying model: customer orientation, connectedness, and competitive intensity.

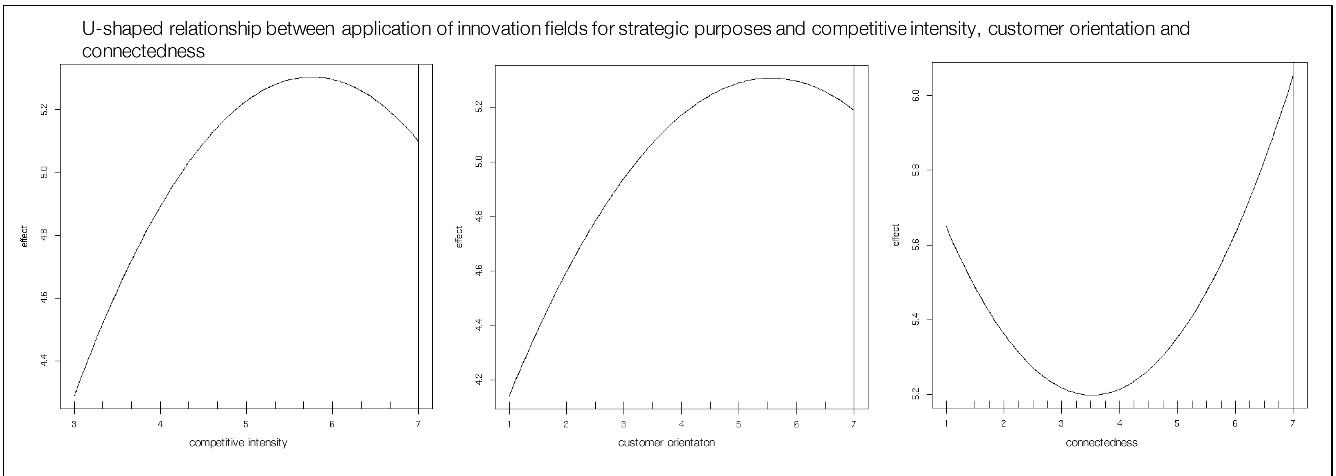


Figure 43: Curvilinear Effects for Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: performed with R-package LinRegInteractive
Effects displayed from left to right: competitive intensity, customer orientation, connectedness

Competitive intensity has a positive impact on the dependent variable and the strongest effect (estimate = 1.53/-0.13). The course reveals a concave curvilinear development. Up to 5.71, competitive intensity shows a positive impact on the intended application of innovation fields for strategic purposes. After this point, the effect is reversed, meaning that in a highly competitive environment the intention to use innovation fields for strategic purposes decreases. Similar to the possible explanation for the general intention to use innovation fields, the adaptability to the environment has to increase to shift activities when competitive intensity rises, thus making innovation fields a less relevant topic, aiming towards imitation or cost reduction (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723).

The convex curvilinear relationship of connectedness towards the intended application of innovation fields for strategic purposes reveals that with low to medium-level interaction (up to 3.6), the application of innovation fields for strategic purposes decreases, while at a high connectedness level the usage increases. In an environment with open and transparent communication between employees and departments, the information regarding innovation strategy can be communicated and distributed best, while at the same time in a less connected context these fields offer a basic understanding of the search scope and boundaries (Luca, Verona, & Vicari, 2010, p. 308). Since only the quadratic term is significant, this effect has to be interpreted with caution.

Furthermore, a significant effect could be detected for customer orientation. The graph shows a concave course, showing a positive relationship up to 5.65, then turning into a negative relationship. This relationship supports the qualitative study, indicating that a very high customer orientation has a reverse effect on the intended application innovation fields for strategic purposes. With a very high customer orientation, innovation fields for strategic purposes are not needed since the customers will articulate their needs and requirements very precisely.

The model shows that formalization has a weak significant negative linear effect (-0.09) on the intended application of innovation fields for strategic purposes. The more formalized the context, the less inclined the respondents are to apply innovation fields for strategic purposes. Interestingly, the qualitative study also showed formalization as an influence on the intended application of innovation fields for strategic purposes, but with a reverse effect direction. The results of the qualitative study show that a formal climate fosters the intended application of innovation fields for strategic purposes. This contradiction will be further elaborated in the discussion chapter.

Both managerial responsibility and process satisfaction have an impact on the application of innovation fields for strategic purposes. Managerial responsibility has a negative impact, while process satisfaction has a positive impact.

Managerial responsibility shows a significant negative effect on the intended application of innovation fields for strategic purposes. This might be the case because executives do not recognize the need for innovation fields for strategic purposes since they do have an overview of all strategic topics. It might even be the case that they feel defensive towards their role as managers. It is part of their job as leaders to formulate the innovation strategy, determining search scope and boundaries that might be counteracted through establishing innovation fields (Waldman & Bass, 1991, p. 175).

Process satisfaction has a significant positive impact on the intended application of innovation fields for strategic purposes.

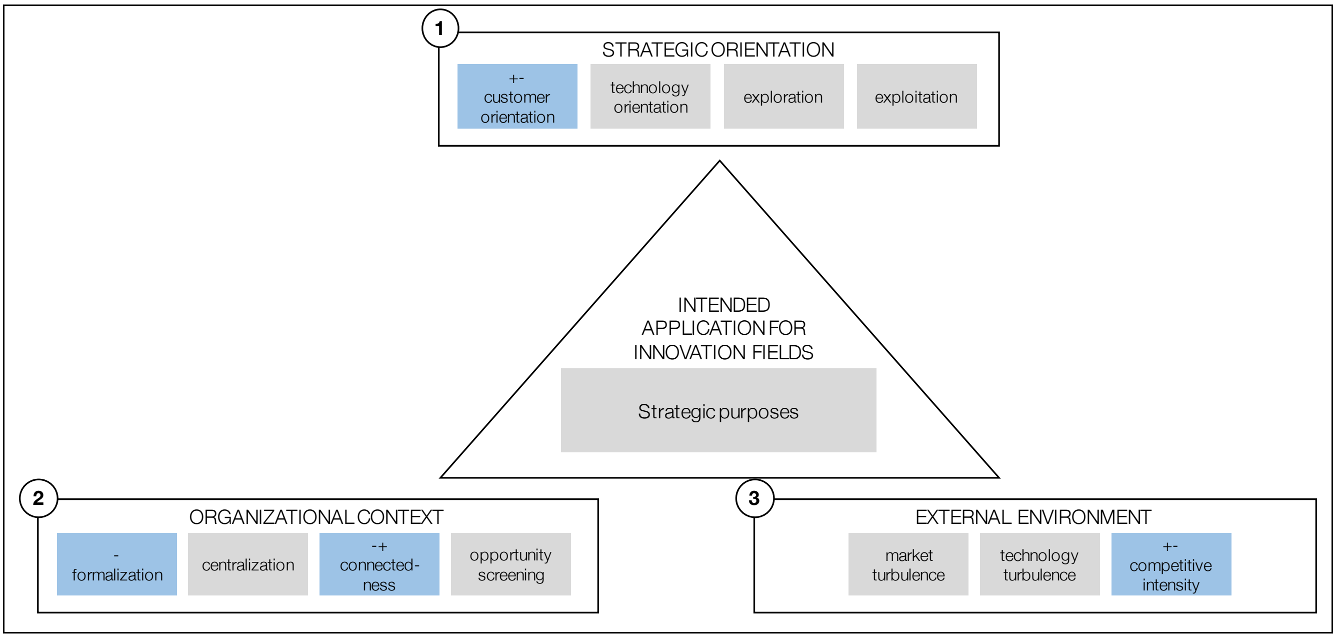


Figure 44: Summary of Results for Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.1.3 Intended Application of Innovation Fields for Ideation

Almost two-thirds of the respondents (68.6%) state their intention to apply innovation fields for ideation. The application for ideation is the second-highest ranking intended type of application of all available choices with 10.5% of respondents ranking it as the main application. About one-third of the respondents (31.4%) claim not to use it at all.

Application of innovation fields for ideation	No. of responses	%
Main application (Rank 1)	41	10.5%
Rank 2	70	18.0%
Rank 3	54	13.9%
Rank 4	33	8.5%
Rank 5	18	4.6%
Rank 6	16	4.1%
Rank 7	8	2.1%
Rank 8	13	3.3%
Rank 9	10	2.6%
Rank 10	4	1.0%
No application	122	31.4%

Table 30: Ranking of Intended Application of Innovation Fields for Ideation

Notes:
Source: own representation
Answer dimensions ranking from one to ten

For the model intended application of innovation fields for ideation, the quadratic model was chosen due to the overall better model fit.

The model shows significant effects for exploitation, centralization, competitive intensity, and market turbulence. Additionally, a significant effect is shown for the control variable process satisfaction and the unit factor. Connectedness, technology turbulence, and managerial responsibility are part of the regression model, albeit without significant effects.

The complete model is highly significant (p-value: 0.000), and the independent variables explain 12.14% of the variance of the dependent variable.

Controls & quadratic main effects

Dependent variable: application of innovation fields for ideation					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-1.803	2.170	-0.831	0.407	
Exploitation	0.131	0.067	1.946	0.052	.
Centralization	0.076	0.043	1.754	0.080	.
Connectedness	-0.444	0.364	-1.218	0.224	
Connectedness^2	0.061	0.040	1.514	0.131	
Technology turbulence	0.114	0.078	1.468	0.143	
Competitive intensity	1.423	0.704	2.021	0.044	*
Competittive intensity^2	-0.142	0.065	-2.183	0.030	*
Market turbulence	0.839	0.444	1.889	0.060	.
Market turbulence^2	-0.095	0.049	-1.913	0.057	.
Unit 2: Software Systems	-0.759	0.233	-3.253	0.001	**
Unit 3: Consumer Goods	0.316	0.334	0.946	0.345	
Unit 4: Materials & Sensors	-0.117	0.219	-0.534	0.594	
Unit 5: Components	-0.075	0.247	-0.302	0.763	
Unit 6: Manufacturing Tech.	-0.279	0.232	-1.206	0.229	
Process satisfaction	0.225	0.053	4.219	0.000	***
Responsibility	-0.309	0.200	-1.542	0.124	
F-statistic: 4.272 on 16 and 363 DF	p-value: 1.18e-07				
Residual standard error: 1.269 on 363 degrees of freedom					
Multiple R^2: 0.1585	**Adjusted R^2: 0.1214**				

Table 31: Regression Model for Intended Application of Innovation Fields for Ideation

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The strongest effect in the model is competitive intensity. The relationship is inversely U-shaped, whereby up to a certain point (5.07) competitive intensity has a positive impact, before turning into a negative relationship. The same type of relationship could be detected for market turbulence. Up to a certain point (4.39) market turbulence has a positive impact. After the inflection point, the tendency to apply innovation fields for ideation decreases. Interestingly, Spanjol et al. (2011) show that market turbulence has an impact on the number of ideas generated in organizations (Spanjol et al., 2011, p. 244). This finding could indicate that market turbulence leads to more attention to the ideation process. This effect reverses at very high levels of market turbulence, where slack resources might be reduced to obtain cost advantages on the market (Shalley & Gilson, 2004, p. 39).

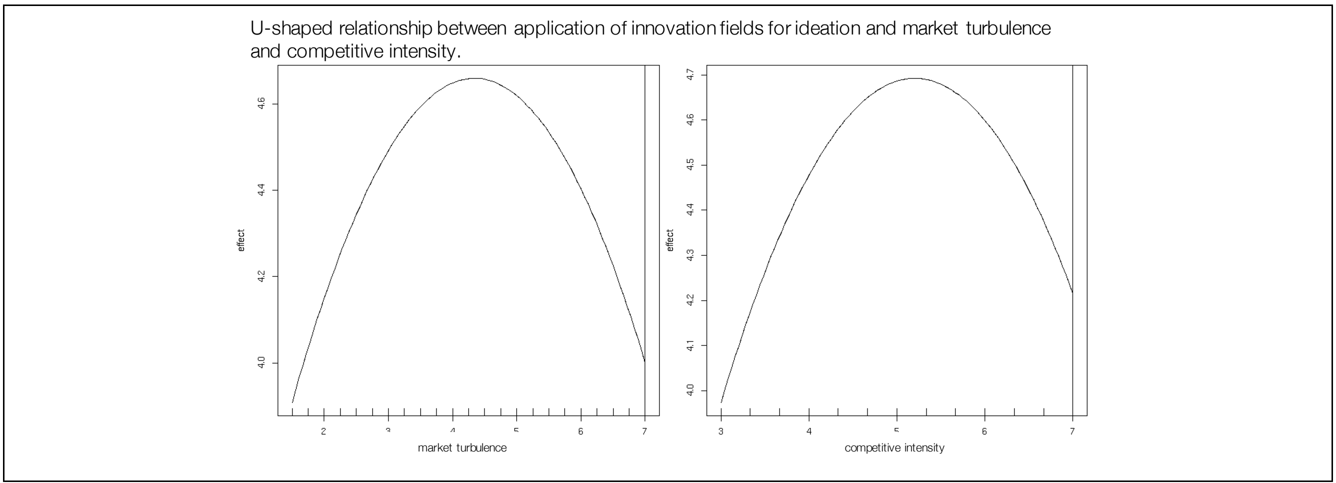


Figure 45: Curvilinear Effects for Intended Application of Innovation Fields for Ideation

Notes:
Source: performed with R-package LinRegInteractive
Effects displayed from left to right: market turbulence, competitive intensity

There is a significant positive effect for exploitation, indicating that the tendency towards using innovation fields for ideation is higher with an exploitation-oriented strategy. Exploitation focuses on the current capabilities and technologies. This orientation is linked to incremental ideas and the refinement of existing knowledge (March, 1991, p. 78). This finding is especially interesting in conjunction with market turbulence and competitive intensity, which indicates that under high external pressure ideation is focused on existing knowledge and refinement. The study by Katila and Ahuja (2002) presents a more comprehensive picture of the exploitation term. Besides the refinement of existing technologies, new knowledge is created through the combination of existing solutions, mastering existing technologies in a more profound way (Katila & Ahuja, 2002, p. 1191; Levinthal & March, 1981, p. 311). In the context of the intended application of innovation fields for ideation, this implies that this type of application is perceived as useful for systematical and structured ideation processes.

The model shows that centralization has a weakly significant positive linear effect on the intended application of innovation fields for ideation. This indicates that the more centralized the climate, the more likely researchers use innovation fields for ideation.

Process satisfaction has a significant positive impact on the application of innovation fields for ideation. Furthermore, a distinction can be detected among the different research units. A significant negative effect for Unit 2: Software Systems is shown in the model. The unit lies at a lower level regarding the intended application of innovation fields for ideation in comparison to the other research units. Interestingly, in the qualitative study, the main type of application for Unit 2: Software Systems was lifting synergies, explaining the lower level intention to apply innovation fields for ideation. Furthermore, as discussed in Chapter 4.4.1.3, software engineering differs regarding the level of turbulence and working habits, which might explain this finding. Furthermore, no interviewee from the qualitative study mentioned ideation as a potential application. Thus, this finding is in line with the qualitative study and ideation might not be the primary focus of software engineers, since their way of working does not include idea generation. Figure 46 summarizes the findings of the regression model.

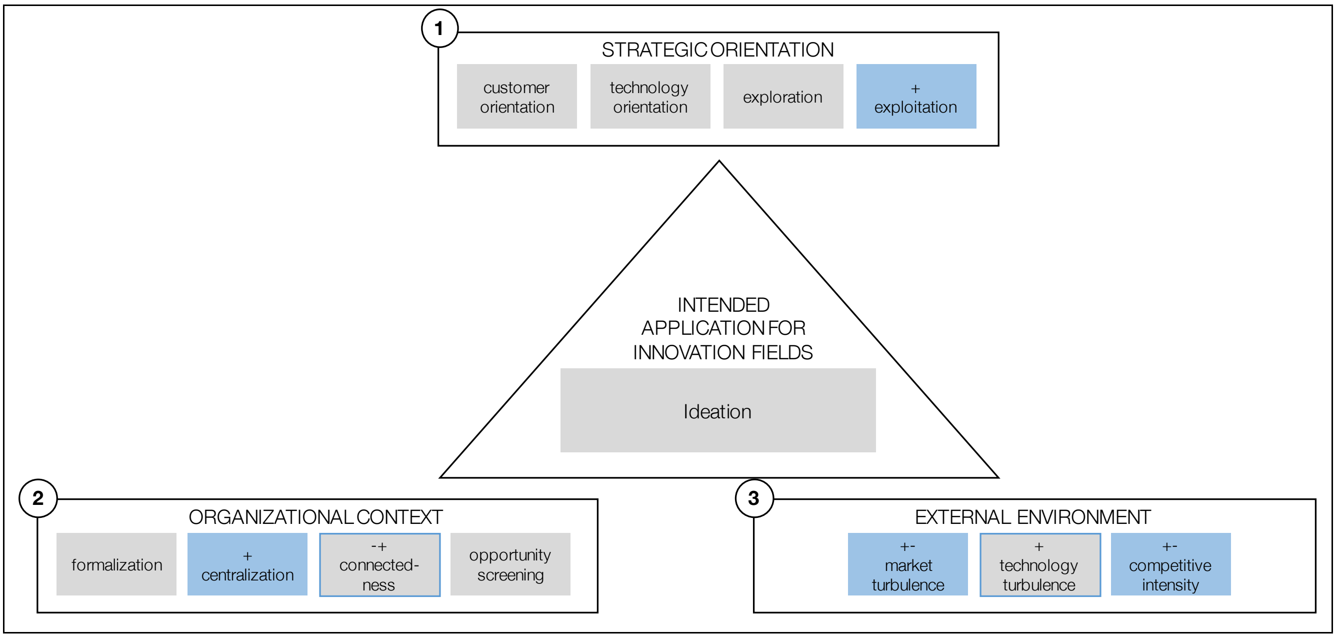


Figure 46: Summary of Results for Intended Application of Innovation Fields for Ideation

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.1.4 Intended Application of Innovation Fields for Lifting Synergies

The ranking variable reveals the intended application of innovation fields for lifting synergies as the third-most ranked intended application. 9.8% of respondents rank lifting synergies as the most important application, while one-quarter of respondents (25.7%) state not to use it at all. Three-quarters of respondents rank using innovation fields for lifting synergies in-between, indicating that it holds some relevance.

Application of innovation fields for lifting synergies	No. of responses	%
Main application (Rank 1)	38	9.8%
Rank 2	58	14.9%
Rank 3	67	17.2%
Rank 4	58	14.9%
Rank 5	32	8.2%
Rank 6	16	4.1%
Rank 7	6	1.5%
Rank 8	3	0.8%
Rank 9	10	2.6%
Rank 10	1	0.3%
No application	100	25.7%

Table 32: Ranking of Intended Application of Innovation Fields for Lifting Synergies

Notes:
Source: own representation
Answer dimensions ranking from one to ten

For the model application of innovation fields for lifting synergies, the linear model was chosen. The integration of quadratic terms did not significantly improve model fit. The model shows significant effects for exploration and technology turbulence. Additionally, significant effects can be shown for the control variables process satisfaction, the unit affiliation and managerial responsibility.

The complete model is highly significant (p-value: 0.000), and the independent variables explain 11.5% of the variance of the dependent variable.

Controls & main effects					
Dependent variable: application of innovation fields for lifting synergies					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.946	0.383	10.314	0.000	***
Exploration	0.139	0.057	2.459	0.014	*
Technology turbulence	0.106	0.063	1.692	0.092	.
Unit 2: Software Systems	-0.620	0.205	-3.022	0.003	**
Unit 3: Consumer Goods	-0.245	0.298	-0.821	0.412	
Unit 4: Materials & Sensors	-0.098	0.197	-0.496	0.620	
Unit 5: Components	-0.251	0.220	-1.140	0.255	
Unit 6: Manufacturing Tech.	-0.037	0.203	-0.181	0.856	
Process satisfaction	0.151	0.049	3.091	0.002	**
Responsibility	-0.536	0.178	-3.006	0.003	**
F-statistic: 6.472 on 9 and 370 DF		p-value: 1.455e-08			
Residual standard error: 1.15 on 370 degrees of freedom					
Multiple R^2: 0.136		**Adjusted R^2: 0.115**			

Table 33: Regression Model for Intended Application of Innovation Fields for Lifting Synergies

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The strongest effect in the model is exploration, with a significant positive linear relationship (estimate: 0.139) towards the intended application of innovation fields for lifting synergies. The more explorative the strategic orientation, the more likely that the researchers intend to use innovation fields for lifting synergies. Having an explorative strategy requires building up new knowledge and competencies, pushing R&D personnel to search for new potential knowledge sources (March, 1991, p. 71). For an explorative orientation, it is crucial to integrate knowledge from different knowledge domains, such as other R&D units or external partners (Poetz & Prügl, 2010, p. 900). This finding is in line with a study from Katila and Ahuja (2002), ascertaining that the width of the search scope has a positive impact on new products (Katila & Ahuja, 2002, p. 1189). Furthermore, in the context of acquiring new information via partnerships, innovation fields pose a means for collaborative understanding and definition of the topic in question, opting as an instrument for communication and knowledge transfer (Gillier et al., 2010, p. 894; Hatchuel et al., 2001, p. 12).

Additionally, a weak positive linear relationship with technology turbulence is found. The more turbulent the technological environment, the greater the tendency towards using innovation fields for lifting synergies. This finding is in line with the qualitative study. In a turbulent and complex environment, synergetic behavior and the autonomy to choose where to search for new knowledge and which partnerships to follow are crucial (Persaud, 2005, p. 423). In a technologically turbulent environment, lifting synergies is required to obtain knowledge from different perspectives and stakeholders, as well as ensuring flexibility in times of rapid change (Candi et al., 2013, p. 135).

Process satisfaction has a significant positive impact, while managerial responsibility shows a negative impact towards using innovation fields for lifting synergies. Furthermore, a distinction can be detected among the different research units. A significant negative effect of the research Unit 2: Software Systems is shown in the model. This indicates that this unit is at a lower level regarding the intended application of innovation fields for lifting synergies.

This finding is not in line with the qualitative study, where respondents from Unit 2: Software Systems declared the application of innovation fields for lifting synergies. This will be further discussed in the next chapter.

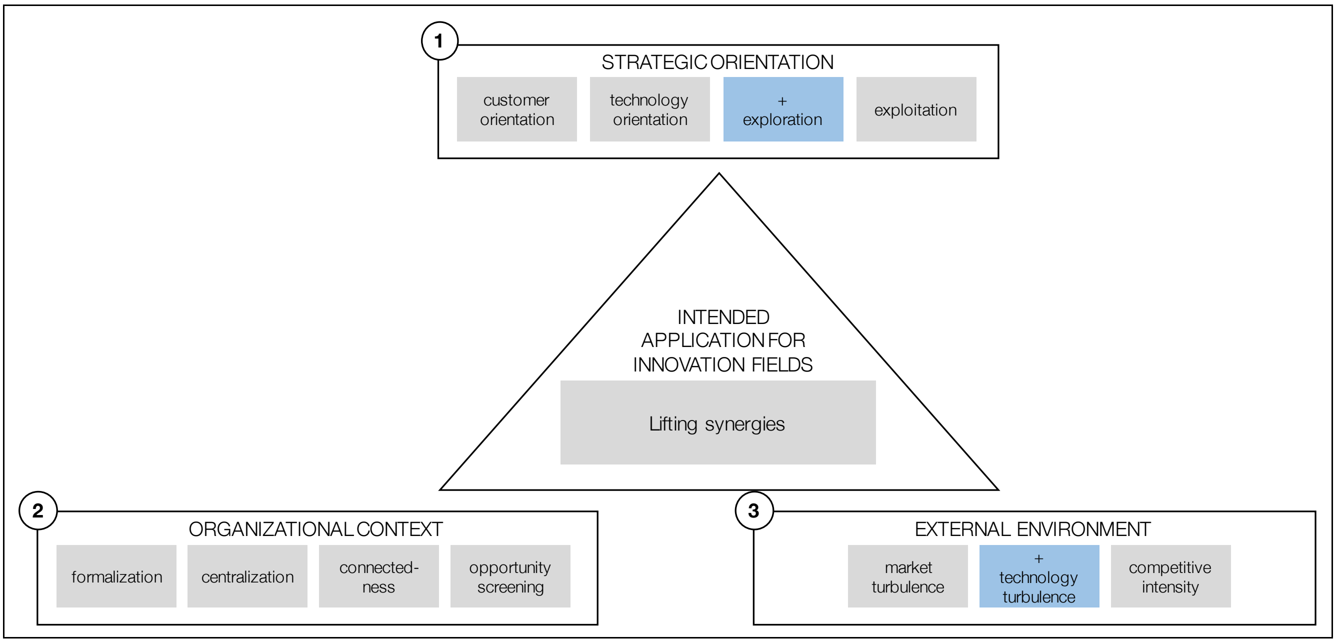


Figure 47: Summary of Results for Intended Application of Innovation Fields for Lifting Synergies

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.1.5 Intended Application of Innovation Fields for Technology Intelligence

5.9% of respondents declared innovation field application for technology intelligence as the main type of application. About half of the respondents (46.0%) ranked technology intelligence as an intended application with medium priority, while 48.1% did not choose it as an intended application. The analysis of the distribution of individual ranks for types of applications indicates that using innovation fields for technology intelligence is an application with a low to medium priority.

Application of innovation fields for technology intelligence	No. of responses	%
Main application (Rank 1)	23	5.9%
Rank 2	24	6.2%
Rank 3	37	9.5%
Rank 4	27	6.9%
Rank 5	34	8.7%
Rank 6	15	3.9%
Rank 7	12	3.1%
Rank 8	13	3.3%
Rank 9	16	4.1%
Rank 10	1	0.3%
No application	187	48.1%

Table 34: Ranking of Intended Application of Innovation Fields for Technology Intelligence

Notes:
Source: own representation
Answer dimensions ranking from one to ten

For the model application of innovation fields for technology intelligence, the quadratic model was chosen due to the better overall model fit.

The model shows significant effects for exploration, technology orientation, and competitive intensity. Furthermore, the model shows significant effects on the control variables process satisfaction, managerial responsibility as well as the unit affiliation. The complete model is highly significant (p-value: 0.000), and the independent variables explain 14.87% of the variance of the dependent variable.

Controls & quadratic main effects					
Dependent variable: application of innovation fields for technology intelligence					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-0.707	1.856	-0.381	0.704	
Technology orientation	0.122	0.071	1.729	0.085	.
Exploration	0.128	0.066	1.938	0.053	.
Competitive intensity	1.549	0.688	2.252	0.025	*
Competitive intensity^2	-0.155	0.064	-2.435	0.015	*
Unit 2: Software Systems	-1.024	0.233	-4.406	0.000	***
Unit 3: Consumer Goods	-0.353	0.322	-1.094	0.275	
Unit 4: Materials & Sensors	-0.253	0.221	-1.147	0.252	
Unit 5: Components	-0.231	0.247	-0.936	0.350	
Unit 6: Manufacturing Tech.	-0.145	0.224	-0.645	0.519	
Process Satsfaction	0.187	0.055	3.416	0.001	***
Responsibility	-0.371	0.199	-1.868	0.063	.
F-statistic: 7.017 on 11 and 368 DF		p-value: 8.196e-11			
Residual standard error: 1.27 on 368 degrees of freedom					
Multiple R^2: 0.1734		**Adjusted R^2: 0.1487**			

Table 35: Regression Model for Intended Application of Innovation Fields for Tech. Intelligence

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Competitive intensity shows a positive effect for the intended application of innovation fields for technology intelligence up until 5.03. After this point, the usage drops and turns negative. As explained in prior models, the adaptability to the environment has to increase to shift activities when competitive intensity rises, making innovation fields a less relevant topic, aiming rather towards imitation or cost reduction (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723). Figure 48 shows the course of competitive intensity in this regression model.

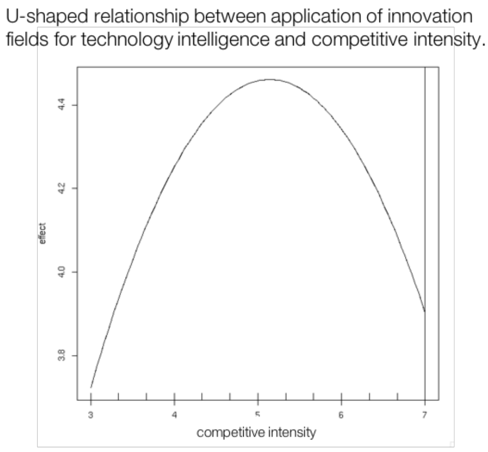


Figure 48: Curvilinear Effect for Intended Application of Innovation Fields for Technology Intelligence

Notes:
Source: performed with R-package LinRegInteractive
Effects displayed: competitive intensity

The model shows a weak significant positive linear effect for exploration, indicating that with an explorative orientation, the intended application of innovation fields for technology intelligence rises. The systematic search for weak signals might be more relevant in an explorative context. Weak signals are especially needed when new information needs to be obtained for product development beyond the current knowledge base. Weak signals can be assigned to each of the innovation fields, ensuring that all employees have the latest information to work with. Additionally, when competitive intensity rises, exploration is more important to beat competitors to market with new products (Auh & Menguc, 2005, p. 1654).

The model shows a significant positive effect for technology orientation. From the qualitative study, it could be obtained that technology intelligence is primarily used in a customer-oriented context and from employees from the technology research area. The question emerges concerning how this contradiction can be explained. Technology intelligence might be a suitable intended application purpose for both strategic orientations. This finding will be further examined in the discussion chapter.

Interestingly, organizational context does not influence the intended application of innovation fields for technology intelligence, while in the qualitative study formalization and centralization showed an influence. This will be further reflected in the discussion chapter.

Process satisfaction has a significant positive impact on the application of innovation fields, and managerial responsibility shows a weak negative impact on using innovation fields for technology intelligence.

Furthermore, a distinction can be detected among the different research units. A significant negative effect of the research Unit 2: Software Systems is shown in the model. This indicates that this unit is at a lower level regarding the application of innovation fields for technology intelligence. This effect is strong (estimate: -1.09) and highly significant, indicating a large difference between the units. Using innovation fields for technology intelligence could be the wrong instrument for the way in which software is developed. This is consistent with the results from the qualitative study, where only one department belonging to Unit 2: Software Systems declared technology intelligence as an intended application of secondary importance. Figure 49 shows the summary of the regression results.

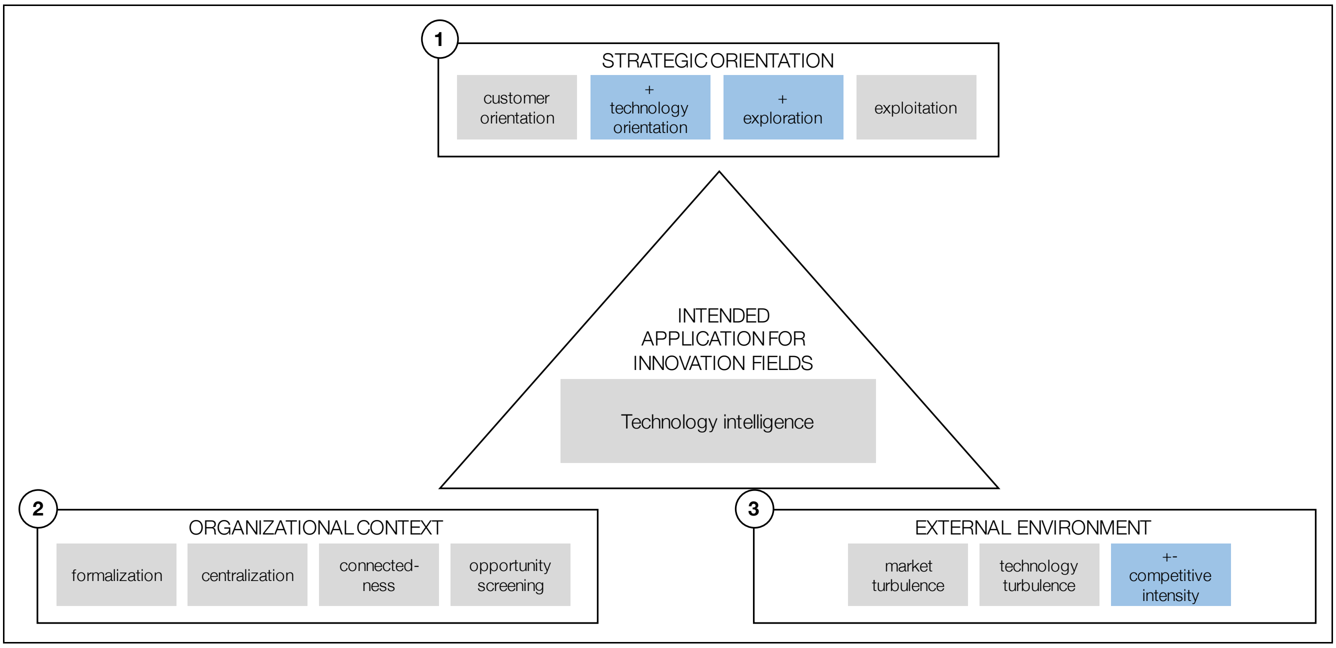


Figure 49: Summary of Results for Intended Application of Innovation Fields for Tech. Intelligence

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.1.6 Intended Application of Innovation Fields for Portfolio Extension

Only 1.0% of the respondents ranked the intended application of innovation fields for portfolio extension as the main type of application, while one-third (37.0%) stated applying innovation fields for portfolio extension, but albeit not as their main type of application. Almost two-thirds of the respondents (63.0%) indicated no application of innovation fields for portfolio extension.

Application of innovation fields for portfolio extension	No. of responses	%
Main application (Rank 1)	4	1.0%
Rank 2	13	3.3%
Rank 3	22	5.7%
Rank 4	17	4.4%
Rank 5	19	4.9%
Rank 6	11	2.8%
Rank 7	15	3.9%
Rank 8	20	5.1%
Rank 9	20	5.1%
Rank 10	3	0.8%
No application	245	63.0%

Table 36: Ranking of Intended Application of Innovation Fields for Portfolio Extension

Notes:
Source: own representation
Answer dimensions ranking from one to ten

For the model intended application of innovation fields for portfolio extension, the linear model was chosen. The integration of quadratic terms did not lead to significantly improved model fit.

The model shows significant effects for technology orientation, technology turbulence, and competitive intensity. Additionally, a significant effect is discovered for the control variables process satisfaction, the unit factor, company tenure and managerial responsibility.

The complete model is highly significant (p-value: 0.000), and the independent variables explain 9.61% of the variance of the dependent variable.

Controls & main effects					
Dependent variable: application of innovation fields for portfolio extension					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.534	0.575	6.142	0.000	***
Technology orientation	0.149	0.068	2.210	0.028	*
Technology turbulence	0.191	0.072	2.642	0.009	**
Competitive intensity	-0.191	0.077	-2.489	0.013	*
Unit 2: Software Systems	-0.979	0.244	-4.014	0.000	***
Unit 3: Consumer Goods	-0.226	0.347	-0.653	0.514	
Unit 4: Materials & Sensors	-0.361	0.232	-1.556	0.121	
Unit 5: Components	0.013	0.263	0.050	0.960	
Unit 6: Manufacturing Tech.	-0.273	0.242	-1.125	0.261	
Process satisfaction	0.097	0.057	1.711	0.088	.
Responsibility	-0.471	0.212	-2.221	0.027	*
Company tenure	0.014	0.008	1.654	0.099	.
F-statistic: 4.666 on 11 and 368 DF		p-value: 1.105e-06			
Residual standard error: 1.33 on 368 degrees of freedom					
Multiple R^2: 0.1224		**Adjusted R^2: 0.09616**			

Table 37: Regression Model for Intended Application of Innovation Fields for Portfolio Extension

Notes
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The strongest effect in the model is competitive intensity, with a significant negative effect (estimate: -0.19) on the intended application of innovation fields for portfolio extension. More competitive intensity leads to less usage of innovation fields for portfolio extension. This indicates that in a highly competitive environment, the focus is set on the successful execution of the current business rather than the extension of new business. This finding is surprising since in a study by Zahra and Covin (1993) it is stated that differentiation and the search for new markets rise under high competitive intensity (Zahra & Covin, 1993, p. 324). On the other hand, competitive intensity can lead to an emphasis on cost reduction and imitation (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723).

Besides competitive intensity, technology turbulence shows a strongly significant positive effect on using innovation fields for portfolio extension. The tendency towards using innovation fields for portfolio extension rises if technology turbulence increases. In times of rapid technological development, resources might be shifted towards discovering new business segments and extending the current portfolio to differentiate on the market (Candi et al., 2013, p. 135).

A positive effect for technology orientation and the intended application of innovation fields for portfolio extension was found. One indication of this result might lie in the nature of the corporate R&D division. Just like in a corporation-supplier relationship, successful suppliers offer new products on a regular basis. Extending the current portfolio and offering new technologies and products to internal customers thus might be a success factor for the R&D division. Additionally, when engaging in advanced development, it is inherent to this task that new segments adjacent to the current portfolio are uncovered. Besides, technology orientation encourages the search for innovation beyond the current portfolio (Spanjol et al., 2011, p. 239).

Process satisfaction and company tenure have a significant positive impact on the intended application of innovation fields for portfolio extension. Additionally, managerial responsibility has a negative impact on the application of innovation fields for portfolio extension and a distinction can be detected among the different research units. A significant negative effect of the research Unit 2: Software Systems can be detected. This indicates that these units are at a lower level regarding the intended application of innovation fields for portfolio extension. The way in which software is developed does not comply with using innovation fields for portfolio extension. This is consistent with the results from the qualitative study, where no software department noted portfolio extension as an intended application and is further elaborated in the discussion chapter. Figure 50 summarizes the findings.

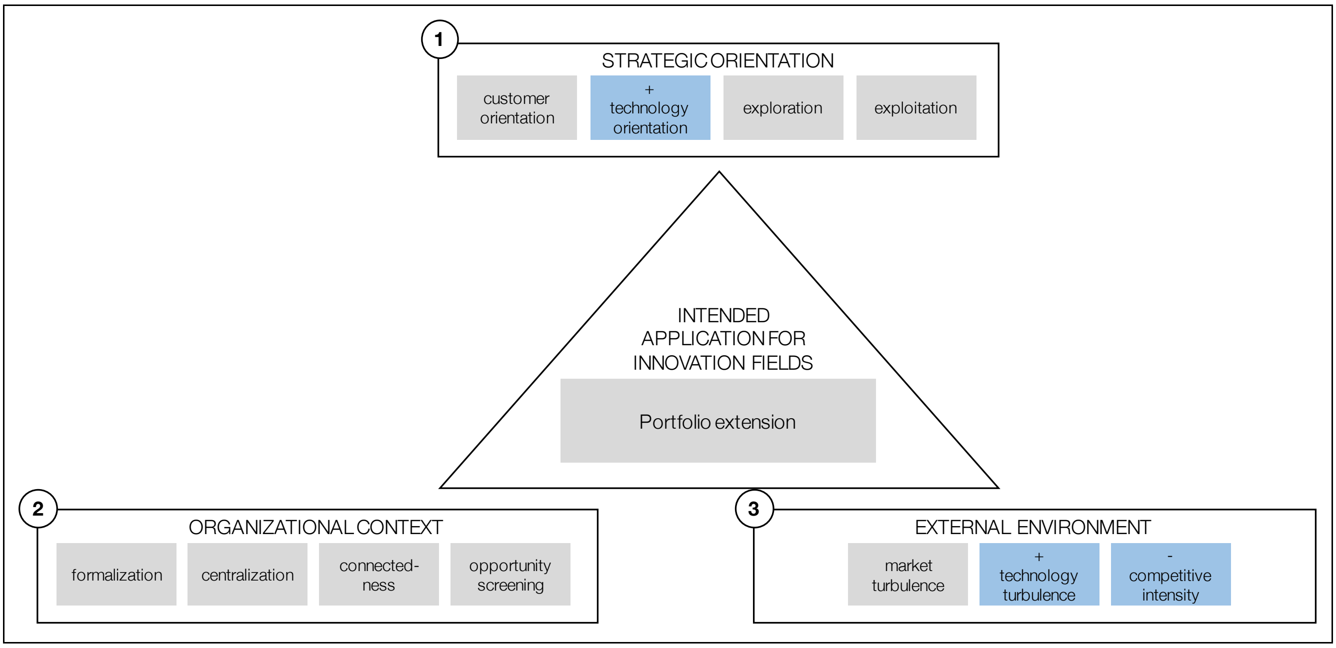


Figure 50: Summary of Results for Intended Application of Innovation Fields for Portfolio Extension

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.2 Results for Perceived Innovation Field Proficiency

After reporting the different intended types of application for innovation fields, the next three chapters outline the individual perceived contextual factors influencing the perceived proficiency of innovation fields. At the time of the qualitative study, the assessment of proficiency of innovation fields could not be obtained due to the limited amount of time between the implementation of innovation fields and conducting the interviews. Therefore, the quantitative part of the study – which was conducted about twelve months later – can obtain the perceived proficiency of innovation fields. The main variable regarding the perceived proficiency of innovation fields is the perceived usefulness of innovation fields, reporting under which circumstances innovation fields are regarded as useful. The other two models are more specific, targeting innovativeness and overall performance.

5.6.2.1 Perceived Usefulness of Innovation Fields

The table below displays the model for the perceived usefulness of innovation fields and shows overall factors influencing the perceived usefulness. For this model, the polynomial model was chosen due to the better overall model fit.

The model shows three significant quadratic effects for customer orientation and market turbulence, as well as a significant linear effect for exploration. Additionally, the control variables process satisfaction and managerial responsibility are significant, and a significant unit factor effect could be detected. Non-significant effects were discovered for connectedness, while for formalization only the quadratic term is significant. This implies that this effect has to be interpreted with caution. The complete model is highly significant (p-value: 0.000), and the independent variables explain 15.39% of the variance of the dependent variable.

Controls & quadratic main effects

Dependent variable: perceived usefulness of innovation fields					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-0.512	1.405	-0.364	0.716	
Customer orientation	1.012	0.371	2.726	0.007	**
Customer orientation^2	-0.102	0.038	-2.732	0.007	**
Exploration	0.120	0.067	1.799	0.073	.
Formalization	-0.501	0.318	1.573	0.117	
Formalization^2	0.059	0.035	-1.687	0.092	.
Connectedness	-0.561	0.360	-1.558	0.120	
Connectedness^2	0.064	0.040	1.627	0.105	
Market turbulence	0.799	0.423	1.891	0.059	.
Market turbulence^2	-0.082	0.047	-1.740	0.083	.
Unit 2: Software Systems	-0.766	0.225	-3.398	0.001	***
Unit 3: Consumer Goods	0.041	0.321	0.127	0.899	
Unit 4: Materials & Sensors	-0.034	0.213	-0.161	0.872	
Unit 5: Components	-0.126	0.236	-0.534	0.594	
Unit 6: Manufacturing Tech.	-0.331	0.216	-1.534	0.126	
Process satisfaction	0.196	0.054	3.647	0.000	***
Responsibility	-0.513	0.191	-2.687	0.008	**
F-statistic: 5.309 on 16 and 363 DF		p-value: 4.198e-10			
Residual standard error: 1.234 on 363 degrees of freedom					
Multiple R^2: 0.1896		**Adjusted R^2: 0.1539**			

Table 38: Regression Model for Perceived Usefulness of Innovation Fields

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Market turbulence shows the strongest effect in the model (estimates: 0.79/-0.08). The graphical display shows a concave relationship with the perceived usefulness of innovation fields. Up to 4.84, market turbulence shows a positive impact on the perceived usefulness of innovation fields. After this point, the effect is reversed, meaning that in a highly turbulent environment the perceived usefulness decreases. With increasing levels of market turbulence, uncertainty reduction is increasingly important, making guiding directions through innovation fields in the front-end of innovation an important means for success (Gatignon & Xuereb, 1997, p. 87). On the other hand, when market turbulence is too high, the usefulness of innovation fields decreases, since innovation fields might feel too hieratic to react to the needs of a very dynamic environment.

Furthermore, a significant effect could be detected for the quadratic term customer orientation. The graph shows a concave course, showing a positive relationship up to 4.89, then turning into a negative relationship. A very high customer orientation has a reverse effect on the perceived usefulness of innovation fields. As mentioned in the qualitative study, with a very high customer orientation, innovation fields might not be needed since the customers will articulate their needs and requirements very precisely.

The effect of formalization on perceived usefulness of innovation has to be interpreted with caution, since only the quadratic term is significant, while the linear term is not. Formalization has a negative impact on the perceived usefulness up to the inflection point of 4.22, then turning into a positive relationship. In low- to medium-formalized climates, they are perceived as less useful, while with very high levels of formalization they are perceived as useful. There are ambiguous results about the type of impact of formalization in the context of innovation. In a study by Kock, Heising and Gemünden (2015), it was shown that process formalization has a positive impact on innovation fields, while Nobelius and Trygg (2002) vouch for more flexibility and less formalization in the front-end of innovation

(Kock et al., 2015, p. 549; Nobelius & Trygg, 2002, p. 338). This finding will be further elaborated in the discussion chapter.

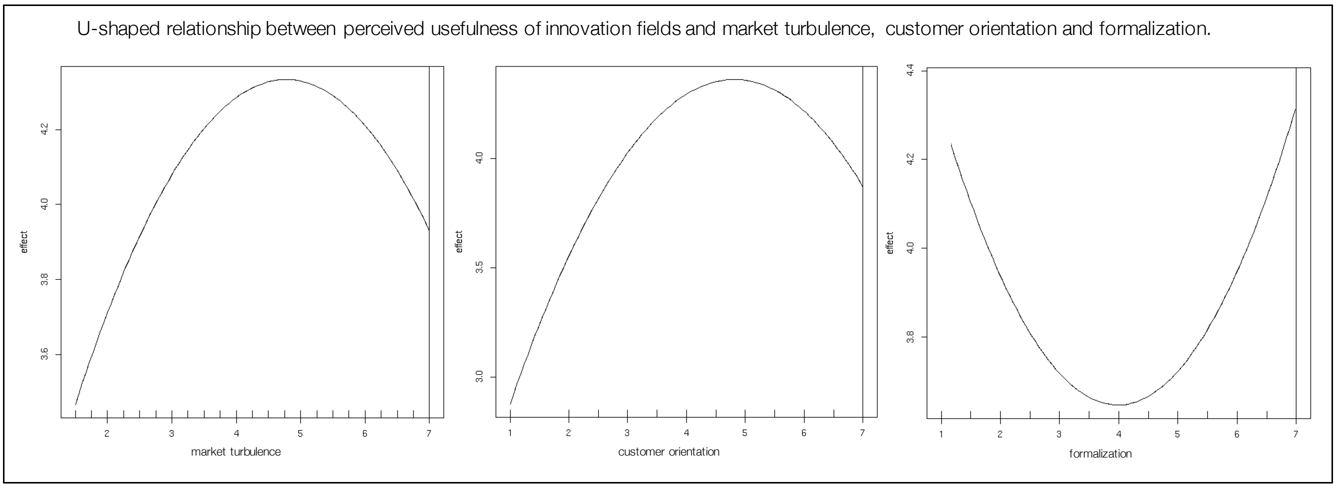


Figure 51: Curvilinear Effects for Perceived Usefulness of Innovation Fields

Notes:
Source: performed with R-package LinRegInteractive
Effects displayed from left to right: market turbulence, customer orientation

Furthermore, exploration has a significant positive linear impact on the perceived usefulness of innovation fields. The more explorative the innovation strategy, the more likely that innovation fields are perceived as useful. Based on the finding regarding market turbulence, innovation fields might give guidance in turbulent times, when search scope and boundaries need to be renewed in order to sustain future success.

Process satisfaction has a significant positive impact on the perceived usefulness of innovation fields, while managerial responsibility has a significant negative effect. Furthermore, a significant effect for unit affiliation could be detected for Unit 2: Software Systems. The effect is negative, meaning that the levels regarding the perceived usefulness of innovation fields are below other research units. This finding is unsurprising, since for Unit 2: Software Systems a significant negative factor effect could be detected for several other innovation field applications. Figure 52 summarizes the findings of the regression models.

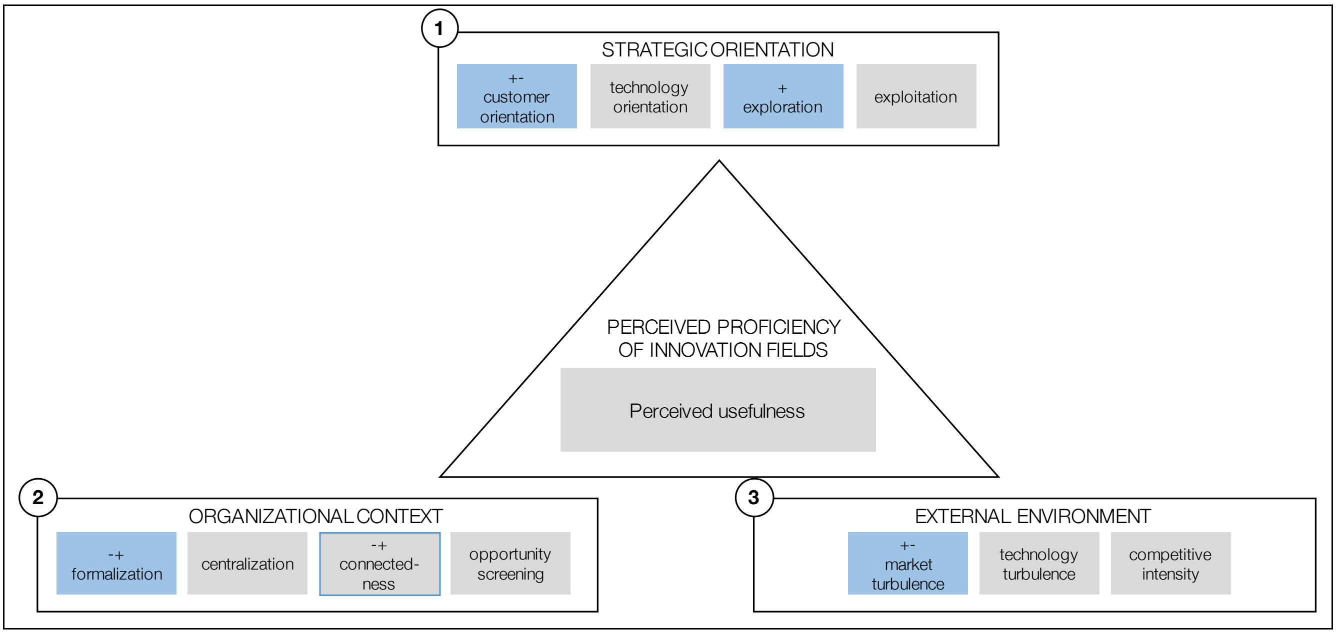


Figure 52: Summary of Results for Perceived Usefulness of Innovation Fields

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.2.2 Innovation Fields Enhancing Performance

For the model for innovation fields enhancing performance, the polynomial model was chosen due to the better overall model fit.

Overall, perceiving innovation fields as performance-enhancing is influenced by two significant quadratic effects for competitive intensity and customer orientation, as well as a significant linear effect for technology turbulence. Additionally, the control variables process satisfaction, managerial responsibility and the unit factor are significant.

The complete model is highly significant (p-value: 0.000), and the independent variables explain 15.28% of the variance of the dependent variable.

Controls & quadratic main effects					
Dependent variable: innovation fields enhancing performance					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-2.507	1.938	-1.294	0.197	
Customer orientation	1.073	0.356	3.015	0.003	**
Customer orientation^2	-0.101	0.036	-2.773	0.006	**
Technology turbulence	0.138	0.066	2.095	0.037	*
Competitive intensity	1.461	0.676	2.161	0.031	*
Competitive intensity^2	-0.150	0.062	-2.409	0.016	*
Unit 2: Software Systems	-0.927	0.224	-4.139	0.000	***
Unit 3: Consumer Goods	-0.132	0.316	-0.416	0.678	
Unit 4: Materials & Sensors	-0.067	0.213	-0.313	0.755	
Unit 5: Components	0.005	0.238	0.020	0.984	
Unit 6: Manufacturing Tech.	-0.329	0.221	-1.490	0.137	
Process satisfaction	0.210	0.051	4.132	0.000	***
Responsibility	-0.414	0.193	-2.142	0.033	*
F-statistic: 6.695 on 12 and 367 DF		p-value: 6.701e-11			
Residual standard error: 1.237 on 367 degrees of freedom					
Multiple R^2: 0.1796		**Adjusted R^2: 0.1528**			

Table 39: Regression Model for Innovation Fields Enhancing Performance

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Two quadratic terms were found to be significant in the underlying model: customer orientation and competitive intensity. Competitive intensity shows the strongest effect in the model (estimates 1.46/-0.15). The graphical display shows a concave relationship for innovation fields perceived as enhancing performance. Up to 4.88, competitive intensity shows a positive impact on innovation fields enhancing performance. After this point, the effect is reversed, meaning that in a highly competitive environment the perceived enhanced performance decreases. This finding is line with studies showing that in the case of rising competitive intensity, performance is raised through greater emphasis on innovation activities to keep up with the competition. On the other hand, with very high levels of competitive intensity, resources are shifted towards imitation or cost-reduction, superseding innovation fields and decreasing performance (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723).

Furthermore, a significant effect could be detected for the quadratic term of customer orientation. The graph shows a concave course, showing a positive relationship up to 5.30, after which the effect saturates. A very high customer orientation has a negative effect on the perception of innovation fields enhancing performance, while at lower levels they are perceived as performance-enhancing. This can be explained due to the fact that with a very high customer orientation, the potential benefit of innovation fields saturates since customers will articulate their needs and requirements very precisely.

U-shaped relationship between innovation fields enhancing performance and competitive intensity and customer orientation.

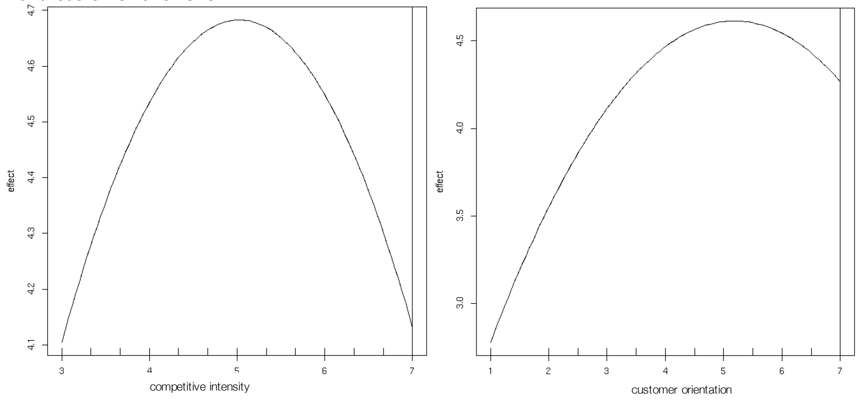


Figure 53: Curvilinear Effects for Innovation Fields Enhancing Performance

Notes:
Source: performed with R-package LinRegInteractive
Effects displayed from left to right: competitive intensity, customer orientation

The model shows that technology turbulence has a weak significant linear positive impact (estimate: 0.14). The more turbulent the environment, the more likely that innovation fields are perceived as enhancing performance.

Interestingly, organizational context variables were not detected to impact the perception of innovation fields enhancing performance.

Process satisfaction has a significant positive impact on innovation fields enhancing performance, while managerial responsibility has a significant negative impact on innovation fields enhancing performance.

Furthermore, a distinction can be detected among the different research units. A significant negative effect for research Unit 2: Software Systems is shown in the model. This indicates that this unit is at a lower level regarding the perception that innovation fields enhance performance. This finding is unsurprising, since for Unit 2: Software Systems a significant negative effect could be detected for several other intended innovation field applications. Figure 54 summarizes the findings of the regression models.

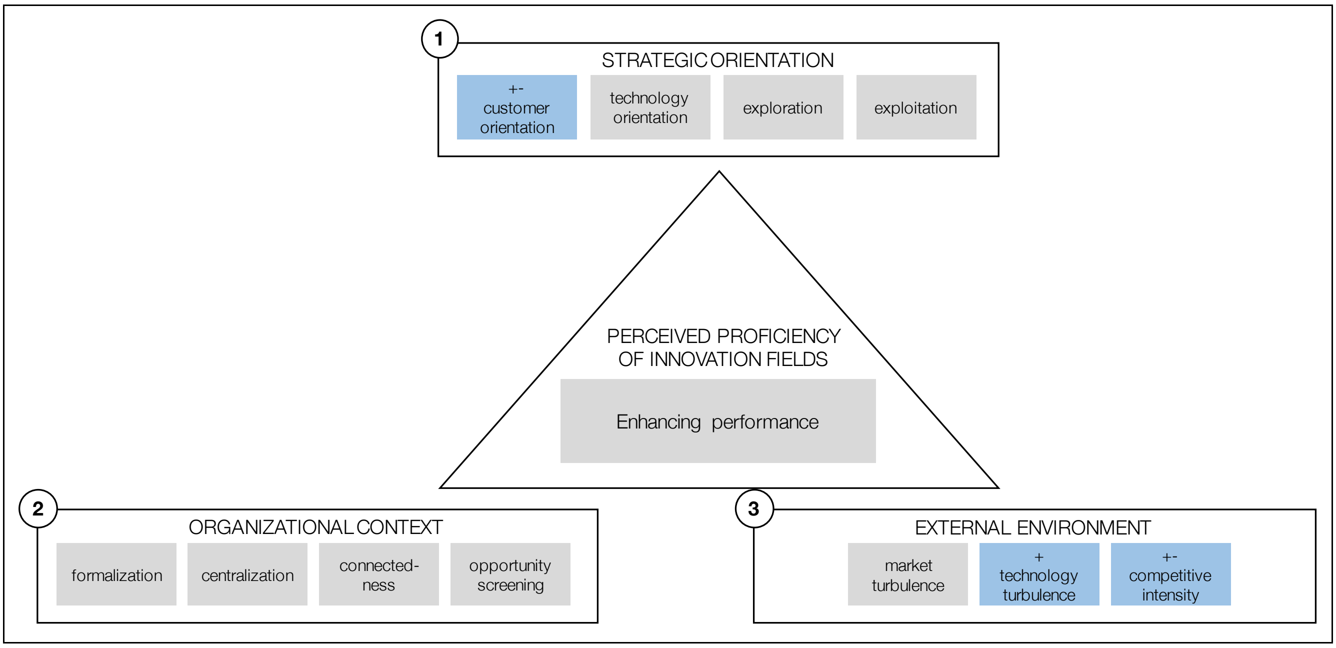


Figure 54: Summary of Results for Innovation Fields Enhancing Performance

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.2.3 Innovation Fields Enhancing Innovativeness

For the dependent variable innovation fields enhancing innovativeness, the linear model was chosen. The integration of quadratic terms did not significantly enhance the model fit. The model shows significant effects for competitive intensity and technology turbulence. Additionally, the control variable process satisfaction is significant, and a significant effect for unit affiliation could be detected. Non-significant effects for market turbulence and managerial responsibility are detected. The complete model is highly significant (p-value: 0.000), and the independent variables explain 10.1% of the variance of the dependent variable.

Controls & main effects					
Dependent variable: innovation fields enhancing innovativeness					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.398	0.554	6.138	0.000	***
Technology turbulence	0.137	0.077	1.768	0.078	.
Competitive intenstiy	-0.134	0.075	-1.795	0.073	.
Market turbulence	0.106	0.073	1.446	0.149	
Unit 2: Software Systems	-1.058	0.233	-4.535	0.000	***
Unit 3: Consumer Goods	-0.273	0.331	-0.824	0.410	
Unit 4: Materials & Sensors	-0.277	0.222	-1.247	0.213	
Unit 5: Components	-0.149	0.249	-0.597	0.551	
Unit 6: Manufacturing Tech.	-0.280	0.230	-1.215	0.225	
Process satisfaction	0.181	0.051	3.507	0.001	***
Responsibility	-0.312	0.202	-1.546	0.123	
F-statistic: 5.267 on 10 and 369 DF		p-value: 2.956e-07			
Residual standard error: 1.293 on 369 degrees of freedom					
Multiple R^2: 0.1249		**Adjusted R^2: 0.1012**			

Table 40: Regression Model for Innovation Fields Enhancing Innovativeness

Notes:
Source: own representation
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Competitive intensity has a negative effect on innovation fields enhancing innovativeness. The usefulness of innovation fields decreases with rising competitive intensity. This finding is in line with a study by Baker and Sinkula (2007), detecting that competitive intensity has a negative impact on innovativeness (Baker & Sinkula, 2007, p. 326). Technology turbulence has a positive impact (estimate: 0.13) on perceived innovativeness. The more turbulent the environment, the more likely that innovation fields are perceived as enhancing innovativeness. Technology turbulence is also an influencing factor for innovation field application for lifting synergies and portfolio extension. Both models require building up new knowledge and the set-up of new information sources to develop new innovation opportunities beyond current business. It can be suggested that by widening the search scope, the potential to find more innovative ideas rises (Candi et al., 2013, p. 135; Katila & Ahuja, 2002, p. 1191).

Process satisfaction has a significant positive impact on perceived enhanced innovativeness and a significant negative effect for the research Unit 2: Software Systems is shown in the model. This indicates that this unit is at a lower level regarding the perception that innovation fields enhance innovativeness. As with the previously presented models, Unit 2: Software Systems seems to be almost systematically less prone to use innovation fields and less convinced that they have a benefit for the organization. This finding will be further discussed in the discussion chapter.

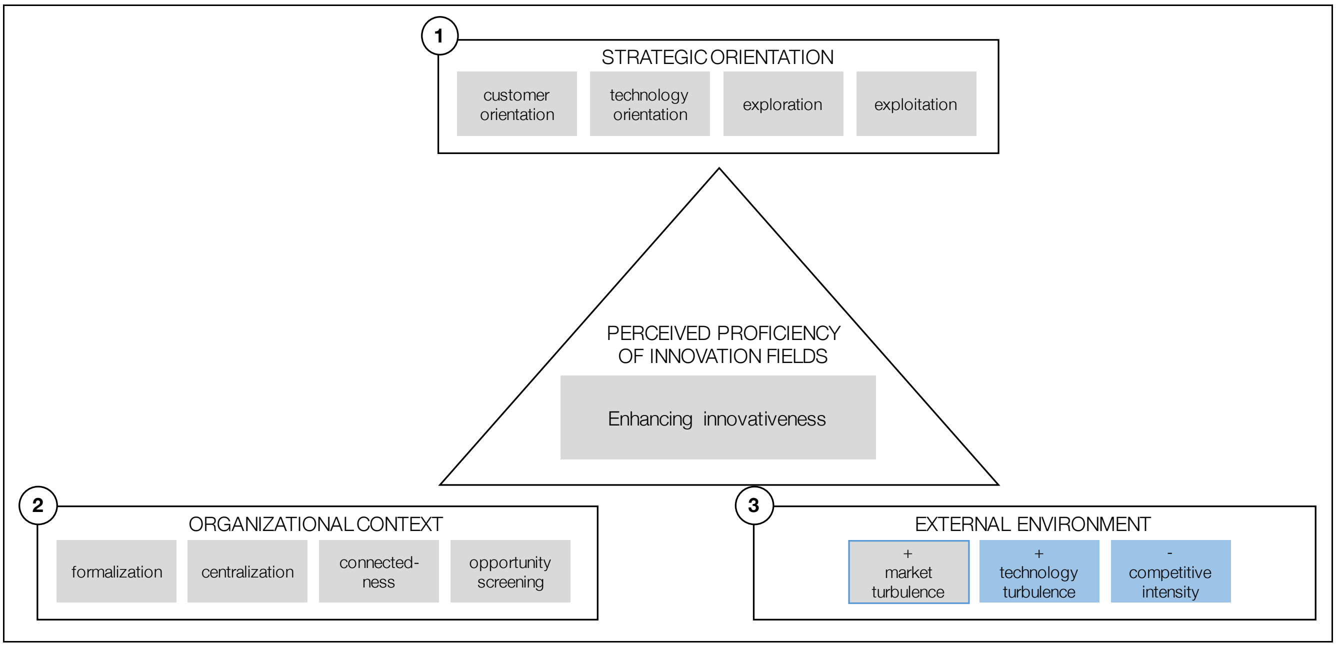


Figure 55: Summary of Results for Innovation Fields Enhancing Innovativeness

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

5.6.3 General Conclusions of Quantitative Results

This chapter draws overall conclusions on the contextual factors of innovation field application. Table 41 shows all intended innovation field applications and perceived proficiency with their corresponding determinants.

	Independent / Dependent variables	Intention to use	Strategic purposes	Ideation	Lifting synergies	Tech. intelligence	Portfolio extension	Perc. usefulness	Performance	Innovativeness
Strategic orientation	Cust. orientation	+-	+-					+-	+-	
	Tech. orientation					+	+			
	Exploration				+	+		+		
	Exploitation			+						
Organizational context	Formalization	-	-					-+		
	Centralization			+						
	Connectedness		-+							
	Opp. screening									
Environment	Market turbulence			+-				+-		
	Tech. turbulence				+		+		+	+
	Comp. intensity	+-	+-	+-		+-	-		+-	-
Controls	Process sat.	+	+	+	+	+	+	+	+	+
	Unit 2: Software S.			-	-	-	-	-	-	-
	Man. responsibility		-		-	-	-	-	-	
	Tenure						+			

Table 41: Summary of Quantitative Results

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

The findings are compared along the clusters strategic orientation, organizational context, external environment, and control variables.

Strategic Orientation

Customer orientation has a significant inverse U-shaped effect for general intention to use innovation fields, innovation fields for strategic purposes as well as perceived usefulness and innovation fields enhancing performance. A positive effect for technology orientation could be detected for the intended application of innovation fields for technology intelligence and portfolio extension. Exploration is significant for the intended application of innovation fields for lifting synergies, technology intelligence and the perceived usefulness of innovation fields. For the intended application of innovation fields for portfolio extension, a significant effect for exploration would have been expected, but could not be detected. Exploitation is only significant for ideation, which is an interesting finding that needs to be further elaborated in the discussion chapter.

Overall, customer orientation and exploration seem to be important contextual factors regarding the intended application and perceived proficiency of innovation fields.

Organizational Context

Formalization has a negative influence on the general intention to use innovation fields, and the intended application of innovation fields for strategic purposes and it has a U-shaped effect on perceived usefulness of innovation fields. Centralization positively influences the intended application of innovation fields for ideation. Connectedness is only significant for the intended application of innovation fields for strategic purposes. Since innovation fields can be an instrument to communicate strategic innovation topics, this finding is line with studies such as Salomo et al. (2008) and Crawford (1980). No influence of connectedness could be detected for the intended application of innovation fields for lifting synergies and portfolio extension, although an effect was expected due to the importance of communication for these types of activities (Michelfelder & Kratzer, 2013, p. 1169). Interestingly, opportunity screening has not been found to be significant for any of the models. It would have been expected for the intended application of innovation fields for technology intelligence or portfolio extension.

Overall, organizational context seems to play a minor role regarding the intended application and perceived proficiency of innovation fields. Different results were expected for formalization and centralization, due to findings from other studies regarding the influence of formalization and centralization in the context of innovation (Auh & Menguc, 2007, p. 1025; Jansen et al., 2006, p. 1663; J. Kim & Wilemon, 2002a, p. 274; Poskela & Martinsuo, 2009, p. 676).

External Environment

Market turbulence is a significant influencing factor for innovation field application for ideation and perceived usefulness. Furthermore, technology turbulence positively influences innovation field application for lifting synergies, portfolio extension as well as innovation fields enhancing performance and innovativeness. Notably, competitive intensity has a significant inverse U-shaped effect for all types of intended applications besides innovation field application for lifting synergies, and the perceived usefulness of innovation fields. It has a negative effect on portfolio extension and innovativeness.

Overall, competitive intensity seems to be an important influencing factor for the intended application of innovation fields. Furthermore, technology turbulence is indicated as an influencing factor for the perceived proficiency of innovation fields.

Control Variables

The unit factor was significant for Unit 2: Software Systems for almost all intended innovation field applications and perceived proficiency besides the intention to use innovation fields and the intended application of innovation fields for strategic purposes. This indicates that Unit 2: Software Systems recognizes innovation fields as an instrument for strategy, but they feel that they are inept for all other types of application and perceived proficiency. There are two potential explanations for this finding: as indicated in the findings of the qualitative study, the working habits differ for the software engineers and might not comply with the way in which innovation fields can be used besides strategic purposes. Furthermore, Unit 2 already had a so-called *future radar* installed and thus did not understand the additional benefit of innovation fields. Additionally, at the time of the study, Unit 2 had to fight with high competitive intensity and tremendous technological advancements and change, forcing them to react flexibly and thus making innovation fields too hieratic to use. Interestingly, managerial responsibility has a negative influence on intended innovation field applications and perceived proficiency throughout the majority of regression models. This could indicate that innovation fields undermine their role perception as executives, explaining the negative influence. They might see the strategic steering of their respective department or unit as their basic function, thus not accepting the implementation of this process step. Work tenure is significant for the intended innovation field application for portfolio extension, indicating that guidance is also welcome for employees working longer for the company.

The next chapter further elaborates on the synthesized findings from the qualitative and quantitative study.

6 Discussion

This chapter discusses the overall findings of the qualitative and quantitative study by merging the findings and matching them with the existing literature in the context of innovation. The chapter is divided according to the intended innovation field applications and their perceived proficiency, followed by a chapter with a general discussion of the results. Figure 56 shows the chapter overview.

STRUCTURE OF CHAPTER 6: DISCUSSION

6.1 Discussion of Innovation Field Applications
- 6.1.1 General Intention to Use Innovation Fields
- 6.1.2 Intended Application of Innovation Fields for Strategic Purposes
- 6.1.3 Intended Application of Innovation Fields for Ideation
- 6.1.4 Intended Application of Innovation Fields for Lifting Synergies
- 6.1.5 Intended Application of Innovation Fields for Portfolio Extension

6.2 Discussion of Innovation Field Proficiency
- 6.2.1 Perceived Usefulness of Innovation Fields
- 6.2.2 Innovation Fields Enhancing Performance
- 6.2.3 Innovation Fields Enhancing Innovativeness

6.3 Discussion of Overall Findings

Figure 56: Chapter Overview of Discussion

Notes:
Source: own representation

6.1 Discussion of Innovation Field Applications

The next chapters discuss the synthesized findings from the qualitative and quantitative study for the general intention to use innovation fields and innovation field applications. The chapters are sorted by the application frequency derived from the quantitative study, and each chapter is subdivided into the contextual factors strategic orientation, organizational context, and external environment and finishes with propositions derived from the discussion.

6.1.1 General Intention to Use Innovation Fields

The synthesized results for general intention to use innovation fields show effects for (1) customer orientation, (2), formalization, centralization and (3) technology turbulence and competitive intensity. Figure 57 shows the synthesis.

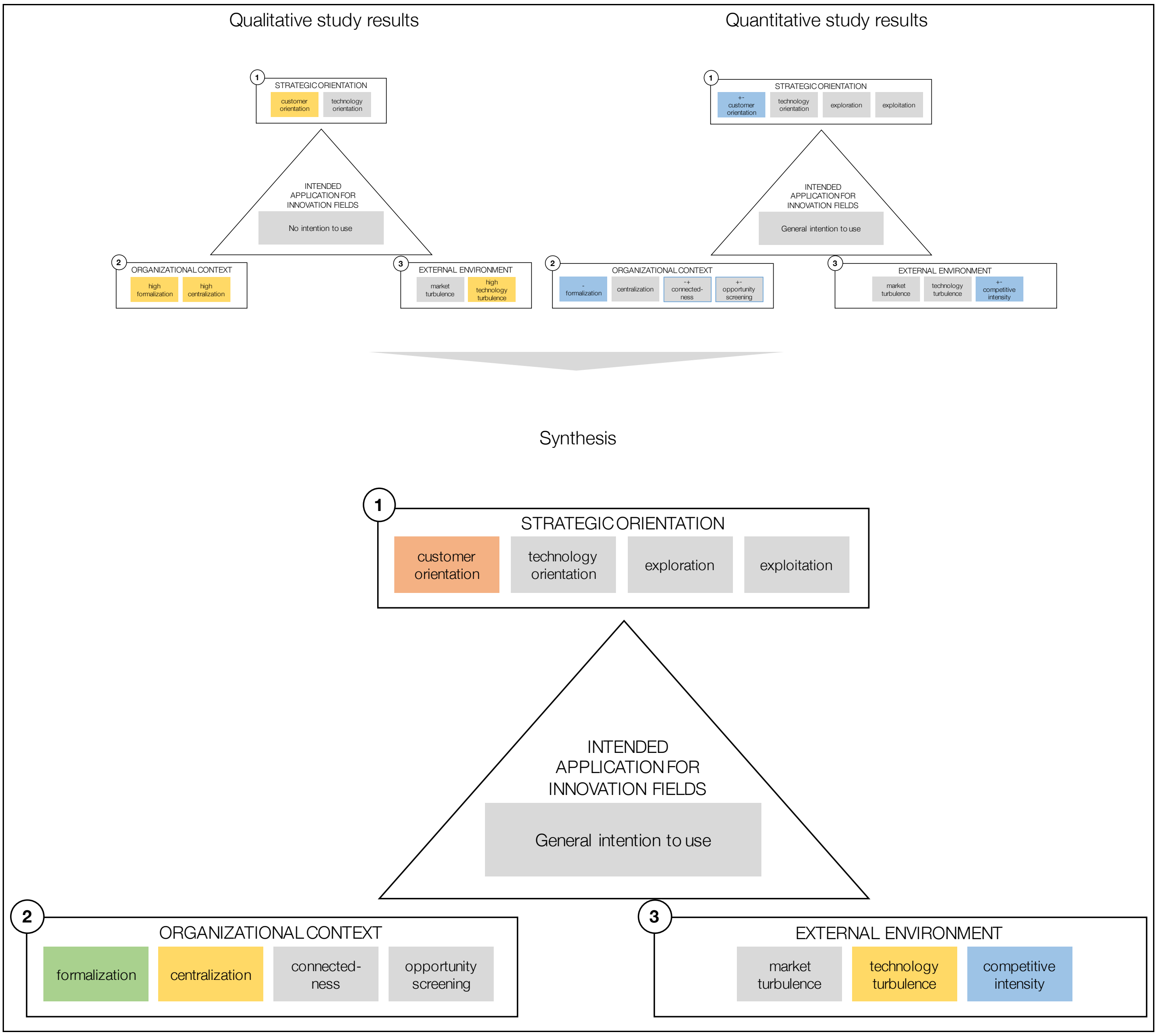


Figure 57: Synthesized Results for General Intention to Use Innovation Fields

Notes:
Source: own representation
Color code: **yellow** = effect from qualitative study; **blue** = effect from quantitative study; **green** = consistent effect in quantitative and qualitative study; **orange** = consistent effect in qualitative and quantitative study, but different effect direction
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

Both the qualitative and quantitative studies reveal an effect for **customer orientation** for the general intention to use innovation fields, albeit with different effect directions. In the qualitative study, customer orientation was considered high for the non-usage cluster, while in the quantitative study a curvilinear inverse-U-shaped relationship could be detected.

In a study by Baker and Sinkula (2007), it was shown that market orientation (in this case tantamount with customer orientation) facilitates the balance between incremental and radical ideas, thus improving the balance between exploration and exploitation (Baker & Sinkula, 2007, p. 317). Consequently, for employees declaring to be customer-oriented, innovation fields might be seen as an instrument for reaching ambidexterity and being perceived as a guiding mechanism.

It can be argued that the curvilinear relationship in the quantitative study and the positive relationship in the qualitative study regarding customer orientation, in fact, correspond to each other. A very high customer orientation led to a decrease in the intention to use innovation fields, while customer orientation was indicated as high for non-usage. In a context with a very high customer orientation, customers will articulate their needs and requirements precisely. Thus, the guidance from customers regarding the scoping of innovation activities might be sufficient, thus making innovation fields unnecessary.

Organizational Context

Both studies revealed **formalization** as a negative influencing factor for the general intention to use innovation fields. Existing studies show a mixed picture regarding the effects of formalization. On the one hand, formalization leads to inflexibility and rigidly following defined work processes, obstructing convergent thinking, creativity, and autonomy. Formalization generates complexity and bureaucracy, demotivating employees and lowering satisfaction (Amabile et al., 1996, p. 1172; Auh & Menguc, 2007, p. 1025; Hartline, Maxham, & McKee, 2000, p. 43; Poskela & Martinsuo, 2009, p. 679). On the other hand, in a study by Kock et al. (2015), a positive influence of formalization on FEI success could be found (Kock et al., 2015, p. 549). Formalization can provide structure through routine creation and standardization, and it reduces deviating understandings of identical activities (Auh & Menguc, 2007, p. 1026). Furthermore, formalization increases comparability, which is especially important for the front-end of innovation, since ideas and concepts need to be compared and evaluated and decisions have to be made concerning the activities upon which to follow up (Martinsuo & Poskela, 2011, p. 904; Montoya-Weiss & O'Driscoll, 2000, p. 160). Equal standards for all ideas supports efficient, transparent and fair assessments of ideas and concepts in the front-end of innovation (Cooper, 2008, p. 221; Kock et al., 2015, p. 544). In the context of the general usage of innovation fields, it seems that the need for leeway weighs stronger than the benefits that formalization can bring.

The qualitative study revealed high **centralization** as a factor negatively affecting intended usage of innovation fields. Interestingly, the quantitative study did not replicate this finding. Studies suggest that centralization accelerates decision-making through the consolidation of information processing. This finding is strengthened in less turbulent market environments, where demand and customer preferences are predictable (Auh & Menguc, 2007, p. 1025; Ruekert, Walker, & Roering, 1985, p. 18). In settings with low centralization, the entrepreneurial spirit is encouraged, leading to increased creativity as well as a higher probability of finding better ideas. It is suggested that employees can judge the relevancy of problems better than executives, due to their greater exposure to relevant topics on a daily basis (Atuahene-Gima, 2003, p. 365; Kock et al., 2015, p. 544). Kock et al. (2015) discovered that autonomy positively influences FEI success (Kock et al., 2015, p. 549). The front-end of innovation is about the discovery of innovation, and low centralization is said to support the initiation of innovation activities and the generation of new ideas (Auh & Menguc, 2007, p. 1025).

External Environment

The qualitative study reveals a positive influence of **technology turbulence** on the general intention to use innovation fields. A study by Candi et al. (2015) shows that technological turbulence positively affects planning flexibility (Candi et al., 2013, p. 138). In the context of innovation fields, it can be argued that in a situation with high technological turbulence, flexible approaches and procedures are needed (Candi et al., 2013, p. 135). Innovation fields can then be used to shift resources from one innovation topic to another quickly. This finding was not replicated in the quantitative study.

Competitive intensity has an inverse U-shaped relationship with the general intention to use innovation fields. This finding is in line with results from Tsai and Yang (2013) regarding competitive intensity and the relationship to innovativeness, stating that “radical competitor attacks” will nullify innovativeness (Tsai & Yang, 2013, p. 1287). In the case of the general intention to use innovation fields, the course of immediate action might require diverging from innovation activities and change direction towards imitation (Baker & Sinkula, 2007, p. 326).

Propositions

From the discussion above, the following propositions are made.

No	Proposition
P1a	*Customer orientation has an inverse U-shaped effect on the general intention to use innovation fields.*
P1b	*Formalization has a negative effect on the general intention to use innovation fields.*
P1c	*Competitive intensity has an inverse U-shaped effect on the general intention to use innovation fields.*

Table 42: Propositions for the General Intention to Use Innovation Fields

Notes
Source: own representation

6.1.2 Intended Application of Innovation Fields for Strategic Purposes

The synthesized results for the intended application of innovation fields for strategic purposes show effects for (1) customer orientation, (2), formalization, connectedness and (3) market turbulence, technology turbulence and competitive intensity. Furthermore, the intended application of innovation fields for strategic purposes is the highest-ranked intended type of application (27%). Figure 58 shows the synthesis.

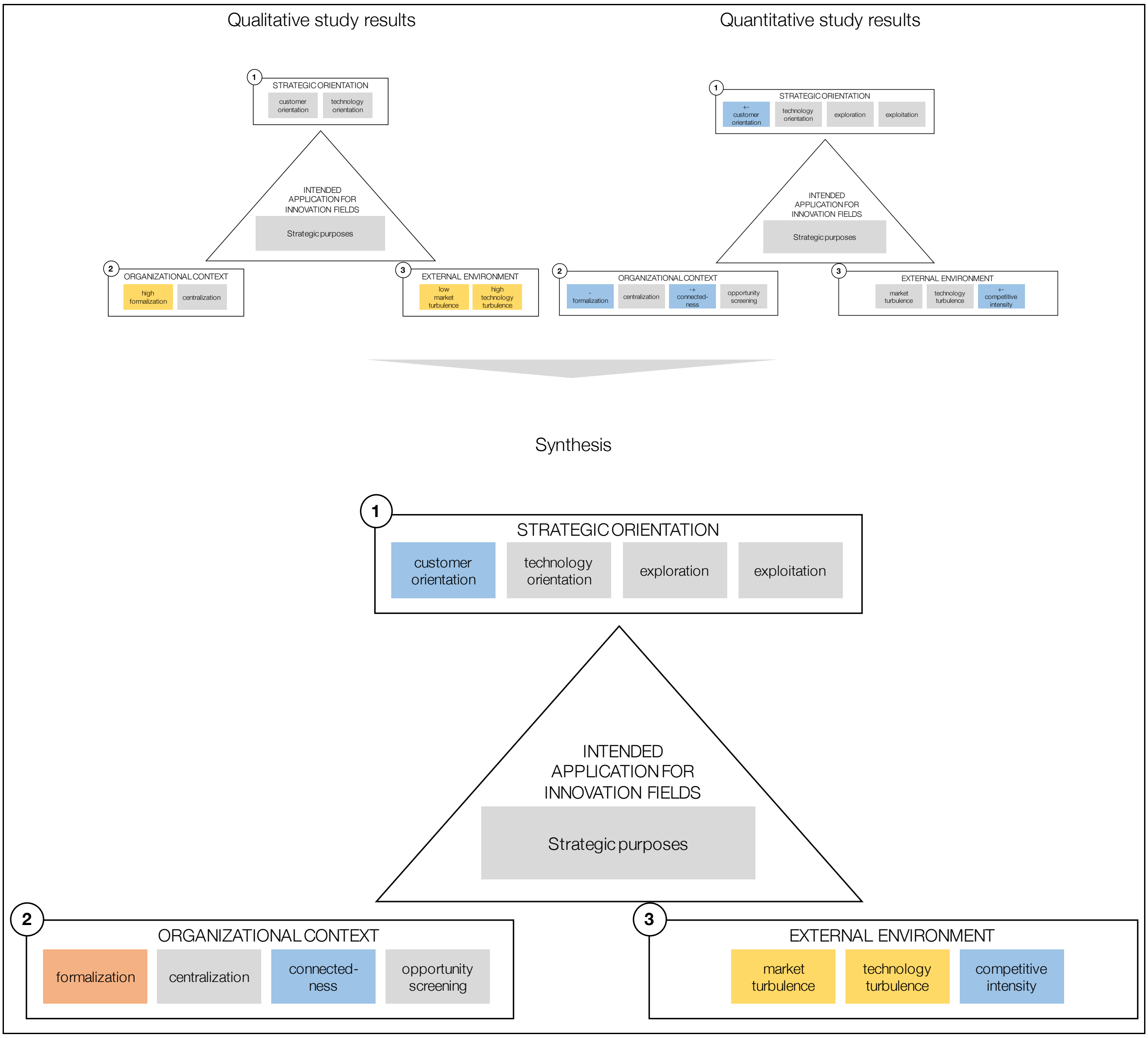


Figure 58: Synthesized Results for Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: own representation
Color code: **yellow** = effect from qualitative study; **blue** = effect from quantitative study; **green** = consistent effect in quantitative and qualitative study; **orange** = consistent effect in qualitative and quantitative study, but different effect direction
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

The intended application of innovation fields for strategic purposes is affected by **customer orientation**. This effect was only significant in the quantitative study, showing an inverse U-shaped relationship. With an orientation towards customers, the intention to use innovation fields for strategic purposes is greater to enforce customer loyalty, satisfaction and increased performance (Auh & Menguc, 2007, p. 1023; Jaworski & Kohli, 1993, p. 57). Customer orientation requires the integration of customer information in the form of, e.g. needs and contacts within the organization (Zahay et al., 2004, p. 661). In a study about information use during NPD, it was highlighted that customer information and needs information is integrated in the front-end activities in the NPD, especially for companies with a strong emphasis on information-sharing (Zahay et al., 2004, p. 663). By using innovation fields for strategic purposes in a customer-oriented setting, needs information, trends and customer requests can be used to derive innovation fields that define the search scope while aligning the scope towards the needs of the customers. Thus, information about customers can be stored in innovation fields and shared accordingly. In a study by Luca et al. (2010), it is argued that a customer orientation can only unfold when there are mechanisms in place, allowing the integration and distribution of information. Consequently, the study results underline the relationship between customer orientation and the intended application of innovation fields for strategic purposes (Luca et al., 2010, p. 314). Furthermore, Baker and Sinkula (2017) show that customer orientation facilitates the balance between incremental and radical ideas (Baker & Sinkula, 2007, p. 317). With the intended application of innovation fields for strategic purposes, a balance between exploitation and exploration can be fostered. On the other hand, a very high level of customer orientation makes the intended application of innovation fields for strategic purposes less relevant, since customers express their requirements and demands accurately. Especially in a B-2-B context with OEMs, the strategy might be primarily determined through the OEM and only complemented through the supplier (Schiele, 2006, p. 927). However, the sole reliance on customer requirements can lead to the neglect of innovation opportunities (Bower & Christensen, 1995, p. 45; Racela, 2014, p. 19).

Organizational Context

There is a discrepancy between the effect direction of **formalization** when using innovation fields for strategic purposes. In the qualitative study, in cases of high formalization, innovation fields are used for strategic purposes. By contrast, in the quantitative study, a low degree of formalization influences the intended application of innovation fields for strategic purposes. A study by Kock et al. (2015) shows a positive effect of process formalization towards FEI success (Kock et al., 2015, p. 548). Process formalization gives guidance and *collective orientation* for the procedures and process steps and in this case the determination of the search scope and boundaries for the department or even the whole R&D division (Tatikonda & Rosenthal, 2000, p. 405). Furthermore, the coordination and effectiveness of activities can be improved since the procedures are universally known and acted upon (Kock et al., 2015, p. 543; Poskela & Martinsuo, 2009, p. 675). Furthermore, formalization is positively associated with decreasing ambiguity and failure reduction (Auh & Menguc, 2007, p. 1024). In opposition, formalization might foster inflexibility and rigidity regarding work procedures, obstructing convergent thinking, creativity, and autonomy. Formalization generates complexity and bureaucracy, demotivating employees and lowering satisfaction (Amabile et al., 1996, p. 1172; Auh & Menguc, 2007, p. 1025; Hartline et al., 2000, p. 43; Poskela & Martinsuo, 2009, p. 679).

The discrepancy of the results might have different reasons. First, initiating or implementing an innovation happens at different stages during the NPD process and thus requires different degrees of formalization (Auh & Menguc, 2007, p. 1027; Damanpour, 1991, p. 569). In retrospect, it is unclear what type of innovation activity the respondents had in mind when indicating the degree of formalization. Second, the difference in effect direction might be explained through different understandings of what formalization actually comprises. Formalization can refer to the strict definition of NPD process steps or the overall bureaucracy in the organization. Future studies should consider this distinction. Third, twelve months had passed after the conduction of the qualitative study. At the time of the quantitative study, employees had a better understanding of innovation fields, which might have led to specific changes in their perception of innovation field application.

Connectedness has a U-shaped relationship with using innovation fields for strategic purposes. With low- to medium-level connectedness, the intended application of innovation fields for strategic purposes decreases, while in a setting with high connectedness the usage increases. This finding finds partial support in a study by Gatignon and Xuereb (1997), finding that interfunctional coordination enhances the effect of strategic orientation. In the context of innovation fields, this implies that strong interdepartmental connectedness influences innovation field application for strategic purposes (Gatignon & Xuereb, 1997, p. 86). Permeability and communication between employees and departments enforce the intended application of innovation fields for strategic purposes since innovation fields are described as an instrument to communicate innovation strategy (Crawford, 1980, p. 11; Salomo et al., 2008, p. 561). In an environment with open and transparent communication between employees and departments, the information regarding the innovation strategy can be communicated and distributed best. This also implies that the prioritization of innovation activities is aligned, which might explain the decrease of the intended innovation field application for strategic purposes at low to medium connectedness levels. In order to establish alignment, a certain threshold of connectedness has to be passed (Luca et al., 2010, p. 308). Following Granovetter (1973) and his study of weak and strong ties, it seems that the curvilinear relationship of connectedness is in line with Granovetter's findings. Weak ties support the generation of ideas and thus no established mechanism to share information is needed. For more complex information, strong ties and thus some degree of connectedness and more refined mechanisms for information storage and distribution is required, such as innovation fields (Granovetter, 1973, p. 1366; Michelfelder & Kratzer, 2013, p. 1160).

Only departments from the technology research area claim to use innovation fields for strategic purposes in the quantitative study. No significant effect for **unit affiliation** could be detected in the quantitative regression model. Thus, the finding from the qualitative study could not be validated in the quantitative study.

External Environment

The qualitative study revealed low **market turbulence** as an indicator for the intended application of innovation fields for strategic purposes. This finding could not be validated in the quantitative study. Tsai and Yang (2013) detect a positive relationship between market turbulence and firm innovativeness, indicating that innovativeness holds particular importance under high market turbulence (Tsai & Yang, 2013, p. 1282). It can be argued that to increase innovativeness, innovation fields for strategic purposes are important to shift resources to fields with a higher probability of yielding more innovative results as a strategic response to changes in the market. This finding contradicts the study results from Tsai and Yang (2013). Other studies, such as Santos-Vijande and Alvarez-Gonzales (2007) or Hult et al. (2004) indicate influence of low levels of market turbulence on innovativeness or find no connection between those two (Hult, Hurley, & Knight, 2004, p. 436; Santos-Vijande & Álvarez-González, 2007, p. 523). In the context of innovation fields, low market turbulence allows for more long-term planning. In this case, innovation fields might be perceived as more useful for strategic purposes than in settings with high market turbulence, where those innovation fields have to be frequently re-defined and shifted.

Interestingly, the intended application of innovation fields for strategic purposes was stated as a type of application under high **technology turbulence** in the qualitative study. This finding was not validated in the quantitative study. A study by Zhou et al. (2005) shows a positive impact of technology turbulence on technology-based innovation (Zheng et al., 2005, p. 51). This means that there is a difference between the various types of turbulence and their impact on the innovation field application for strategic purposes. One explanation might be that technological turbulence requires a certain pressure to plan ahead strategically, due to the longer lead time for R&D innovation activities and thus making innovation fields a more important instrument.

Competitive intensity has an inverse U-shaped relationship with the application of innovation fields for strategic purposes. This finding is in line with results from Tsai and Yang (2013) regarding competitive intensity and the relationship to innovativeness, stating that "radical competitor attacks" will nullify innovativeness (Tsai & Yang, 2013, p. 1287). In the case of intended application of innovation fields for strategic purposes, the course of immediate action might require diverging from innovation activities and change direction towards imitation (Baker & Sinkula, 2007, p. 326). In a highly competitive environment, the adaptability to the environment has to increase to shift activities when competitive intensity rises, making innovation fields a less relevant topic, aiming towards imitation or cost reduction (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723).

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P2a	*Customer orientation has an inverse U-shaped effect on the intended application of innovation fields for strategic purposes.*
P2b	*Competitive intensity has an inverse U-shaped effect on the intended application of innovation fields for strategic purposes.*

Table 43: Propositions for the Intended Application of Innovation Fields for Strategic Purposes

Notes:
Source: own representation

6.1.3 Intended Application of Innovation Fields for Ideation

Ideation was only mentioned as an innovation field application of secondary importance in the qualitative study. Therefore, no distinctive contextual factors from the qualitative study could be obtained. The quantitative study shows effects for (1) exploitation, (2), centralization as well as (3) market turbulence and competitive intensity. Furthermore, the intended application of innovation fields for ideation is the second-highest ranked intended type of application (10.5%). Figure 59 shows the quantitative results.

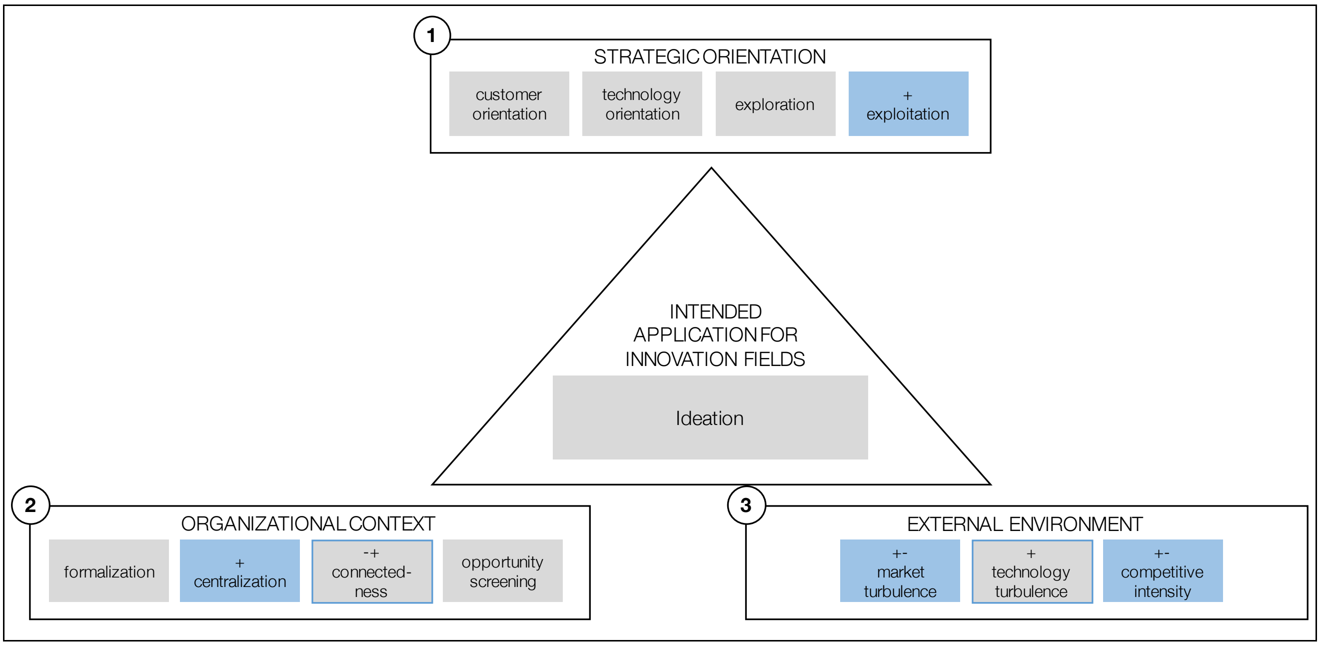


Figure 59: Synthesized Results for Intended Application of Innovation Fields for Ideation

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

The intended application of innovation fields for ideation is positively associated with **exploitation**, indicating that the tendency towards using innovation fields for ideation is higher with an exploitation-oriented strategy. Exploitation focuses on the current capabilities and technologies. This orientation is linked to incremental ideas and the refinement of existing knowledge (March, 1991, p. 78). This finding is especially interesting in conjunction with market turbulence and competitive intensity, which indicates that under high external pressure ideation is focused on existing knowledge and refinement. The study by Katila and Ahuja (2002) presents a more comprehensive picture of the exploitation term. Besides the refinement of existing technologies, new knowledge is created through the combination of existing solutions, mastering existing technologies more profoundly (Katila & Ahuja, 2002, p. 1191; Levinthal & March, 1981, p. 311). Incremental refinement calls for systematic and structured ideation processes, such as TRIZ (Altshuller, 1999) or ideation workshops with a very narrow search scope. In the context of the intended application of innovation fields for ideation, this implies that innovation fields foster those systematical and structured ideation processes.

It is interesting to note that there is no impact of an explorative orientation on intended application of innovation fields for ideation. As outlined in Chapter 2.4.2.2, employees are challenged to think and search beyond existing knowledge and routes (Perkins, 1981, p. 100) when the search scope is restricted. Thus, it was assumed that the systematic generation of ideas with defined innovation fields might increase the probability of finding ideas beyond the current business (Kock et al., 2015, p. 543), which could not be shown in the study.

Organizational Context

Studies suggest that **centralization** accelerates decision-making through the consolidation of information processing (Auh & Menguc, 2007, p. 1025). In the context of innovation fields, idea generation activities are aligned through centralized decisions on the definition of innovation fields. The determined innovation fields act as search boundaries for the search of opportunities while being consistent with strategic choices (Kock et al., 2015, p. 542). This finding is even strengthened in less turbulent market environments, where demand and customer preferences are more predictable (Auh & Menguc, 2007, p. 1025; Ruekert et al., 1985, p. 18). Since market turbulence has a significant inverse U-shaped relationship towards innovation field application for ideation, this finding is supported in this study.

A U-shaped effect for **connectedness** on innovation field application for ideation was part of the model, although not significant. An effect was expected due to studies, showing that modest communication frequency reaps the greatest benefit towards creativity and problem solving and that a divergence from this behavior lowers creative results (Kratzer, Leenders, Van Engelen, & Kunst, 2007, p. 49; J. Zhou, Shin, Brass, Choi, & Zhang, 2009, p. 1547). These results contradict the results of this study. For the intended application of innovation fields for ideation, it might be the case that there is a certain threshold of connectedness to be overcome until this is perceived as an effective measure. Shalley and Gilson (2004) highlight that organizational structures influence creativity (Shalley & Gilson, 2004, p. 45). Having connections to other departments and integrating multiple sources of expertise have a positive influence on creativity (Dougherty & Hardy, 1996, p. 1141). In an innovation field context, this implies that frequent communication is key for fostering the potential of using innovation fields for ideation. For example, several departments can unite to brainstorm ideas, bringing together diverse team backgrounds and thus leading to higher creativity (Amabile et al., 1996, p. 1171; Shalley & Gilson, 2004, p. 43). One interviewee in the qualitative study even mentioned that they have thought about creating a common innovation field for several departments to foster joint idea generation. Thus, it was expected that connectedness enforces the intended innovation field application for ideation through, e.g. joint ideation workshops.

A significant effect for **unit affiliation** was discovered in the quantitative study. Unit 2: Software Systems resides at a lower level regarding innovation field application for ideation. Since interviewees from Unit 2 did not mention this type of application, this finding is in line with the quantitative study.

External Environment

Both **market turbulence** and **competitive intensity** show an inverse U-shaped relationship towards the intended application of innovation fields for ideation. Amabile et al. (2002) found that time pressure hinders creativity: "Under time pressure, people may be less likely to take the time to understand a problem deeply […]. Moreover, they may be less likely to fully think through or talk through the implications of the response possibilities they have generated […]" (Amabile et al., 2002, p. 4). When competitive intensity and market turbulence intensify, the focus on creativity might decrease. Resources are shifted and might be guided towards imitation (Baker & Sinkula, 2007, p. 326). This explains the curvilinear relationship. Up to a certain degree of competitive intensity and market turbulence, there are sufficient slack resources (Shalley & Gilson, 2004, p. 39) to foster creativity, which are then shifted towards imitation or cost reduction. Spanjol et al. (2011) show that market turbulence has an impact on the number of ideas generated in organizations (Spanjol et al., 2011, p. 244). This finding could indicate that moderate market turbulence leads to more attention to ideation and active market search (Spanjol et al., 2011, p. 244).

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P3a	*Exploitation is positively related to the intended innovation field application for ideation.*
P3b	*Centralization is positively related to the intended innovation field application for ideation.*
P3c	*Competitive intensity has an inverse U-shaped effect on the intended innovation field application for ideation.*
P3d	*Market turbulence has an inverse U-shaped effect on the intended innovation field application for ideation.*

Table 44: Propositions for the Intended Application of Innovation Fields for Ideation

Notes:
Source: own representation

6.1.4 Intended Application of Innovation Fields for Lifting Synergies

The synthesized results for the intended application of innovation fields for lifting synergies show effects for (1) technology orientation, exploration (2), formalization as well as (3) market and technology turbulence. Furthermore, the application of innovation fields for lifting synergies is the third highest-ranked intended innovation field intended application (9.8%). Figure 60 shows the synthesized results.

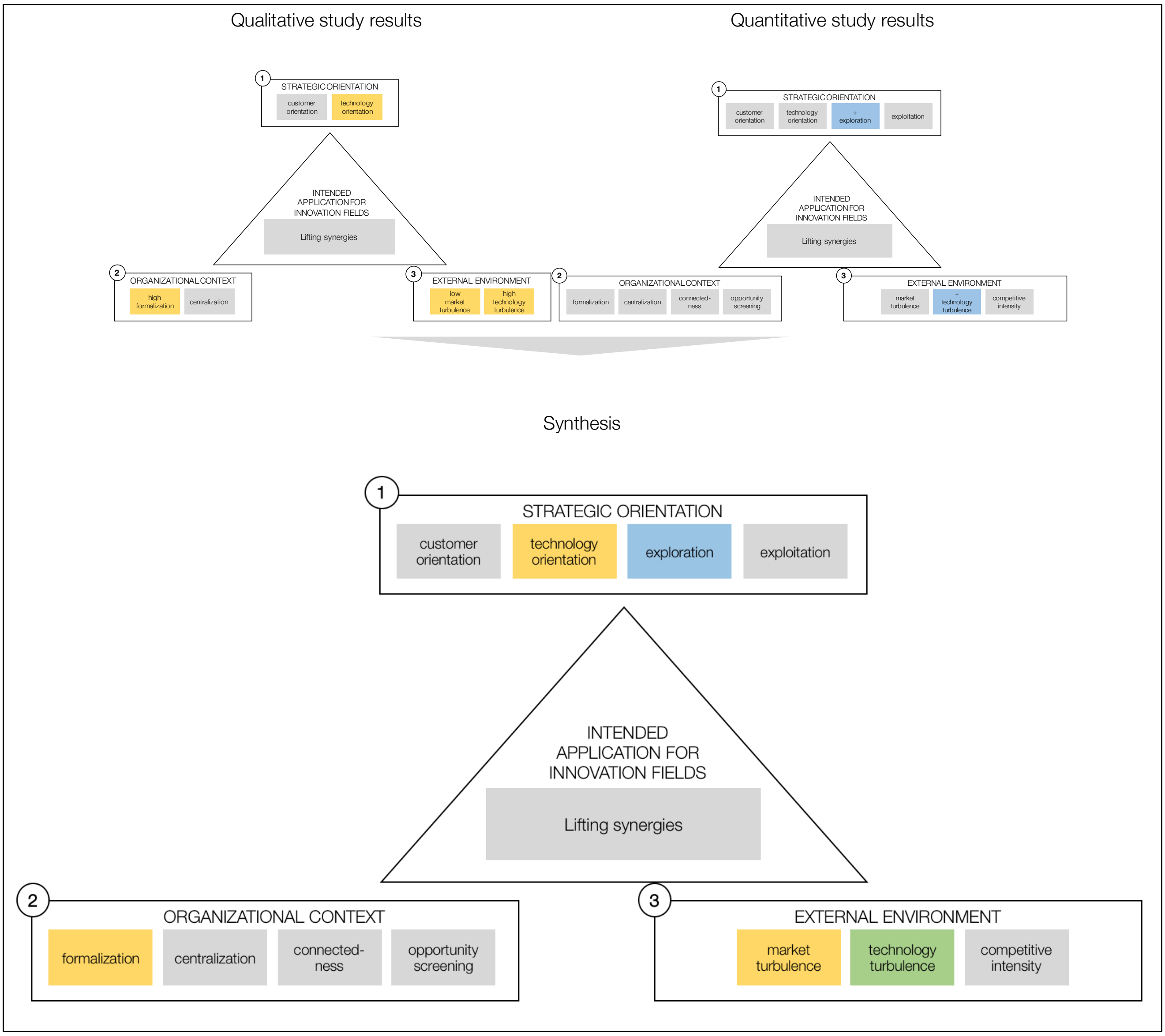


Figure 60: Synthesized Results for Intended Application of Innovation Fields for Lifting Synergies

Notes:
Source: own representation
Color code: **yellow** = effect from qualitative study; **blue** = effect from quantitative study; **green** = consistent effect in quantitative and qualitative study; **orange** = consistent effect in qualitative and quantitative study, but different effect direction
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

Technology orientation has been found to be associated with the intended application of innovation fields for lifting synergies in the qualitative study. This finding could not be validated in the quantitative study. Furthermore, only departments from the technology research area mentioned lifting synergies as an intended application for innovation fields. Technology orientation is associated with the acquisition of new technological knowledge (Spanjol et al., 2011, p. 238). Thus, collaborations are essential, when being technology-oriented, which presents a possible explanation for this finding. As mentioned in the qualitative study, for employees from the technology research area, the connection to other departments and employees with a different skillset is crucial in order to generate ideas, since their working habits differ. To find use cases for novel technologies, the need to collaborate and to lift synergies is greater.

The quantitative study revealed a positive influence on **exploration** for the intended application of innovation fields for lifting synergies. For an explorative orientation, it is crucial to integrate knowledge from different knowledge domains, such as other units from the R&D division or external partners (Poetz & Prügl, 2010, p. 900). Furthermore, in the context of acquiring new information via partnerships, innovation fields pose a means for a collaborative understanding and definition of the topic in question, opting as an instrument of communication and knowledge transfer (Gillier et al., 2010, p. 894; Hatchuel et al., 2001, p. 12). When the search scope is widened, which is the case when the orientation is explorative, having access to information from a network plays an increasing role (Katila & Ahuja, 2002, p. 1189). Similar to the explanation of the technology orientation, it can be argued that with an explorative orientation, the network plays a crucial role in order to gather relevant information. In a study by Michelfelder and Kratzer (2013), it could be shown that the right amount of connectedness has a positive impact on exploration outcomes (Michelfelder & Kratzer, 2013, p. 1171). Thus, in the innovation field context, this could imply that in explorative mode, innovation fields are used as a means for communication and collaboration to gather relevant data. Thus, additionally, a significant effect for **connectedness** would have been expected.

Organizational Context

The quantitative study did not reveal any significant effects for organizational context, while the qualitative study indicated high **formalization** in the case of the intended application of innovation fields for lifting synergies. High formalization reduces divergent guidelines and perspectives for identical tasks (Auh & Menguc, 2007, p. 1025) and provides the base for collaboration and lifting synergies. In a study by Teller et al. (2012), it could be shown that formalization supports synergies in a project portfolio (Teller et al., 2012, p. 603). Synergies can be leveraged through the formalized coordination of information and resource allocation (Teller et al., 2012, p. 603). This relationship is strengthened when the complexity of projects increases. Several studies have found that formalization in the context of innovation leads to a greater interaction rate between different functional areas and thus increased productivity and lifted synergies (Auh & Menguc, 2007, p. 1026; Ayers, Dahlstrom, & Skinner, 1997, p. 112; Rein, 2004, p. 41).

The qualitative study found a difference regarding the way, in which innovation is managed in Unit 2: Software Systems. The adjusted NPD process grants more autonomy to employees regarding budget allocation for innovation activities. IMAs rather than team leads can decide on budget allocation for practical and theoretical studies in the NPD process. Thus, it was assumed that **centralization** might influence the intended application of innovation fields for lifting synergies. Especially the combination of high formalization and low centralization is thought to be beneficial by offering structure and order while preventing rigidity (Auh & Menguc, 2007, p. 1026; Lin & Germain, 2003, p. 1136). However, this finding could not be replicated by the quantitative study.

Furthermore, the qualitative study uncovered a tendency towards the intended application of innovation fields for lifting synergies by Unit 2: Software Systems. This might indicate that there is a difference between software-related projects and other engineering and science projects at the corporate R&D division. As outlined in Chapter 4.4.1.3, scholars have been trying to grasp the essential differences between software development work and other engineering projects. The main differences cover (1) complexity, (2) flexibility and (3) invisibility. Software projects are described as more complex than other engineering projects due to their dependence on hardware development and since written code is not repeatable (Brooks, 1987, p. 13). Furthermore, unlike finished manufactured projects, software can always be changed and adapted and needs to be maintained accordingly (Brooks, 1987, p. 14). It was argued that the way in which software engineers work differs profoundly from other disciplines and has developed over time. This finding is contradictory to the results of the quantitative study indicating a lower usage level for Unit 2. When asked in the qualitative study, innovation fields had just been implemented, and thus the intended application for lifting synergies was an expression of the initial intention. In the meantime, the experiences gained with innovation fields might have changed the perspective towards the potential application of innovation fields for Unit 2. Furthermore, the qualitative study only asked representatives of the respective unit, which are not generalizable to the individual intended applications of innovation fields. Since Unit 2: Software Systems is at a lower level throughout several regression models, this finding will be discussed in Chapter 6.3.

External Environment

The qualitative study indicated low **market turbulence** for the intended application of innovation fields for lifting synergies. This finding was not validated in the quantitative study. As outlined in Chapter 4.4.1.3, it is assumed that tremendous novelties in the software industry – such as the *Internet of Things*[27] – might explain this finding. Software is seen as one of the major enablers of IoT and the area in which most business value will be created (Atzori et al., 2010, p. 2883; Manyika et al., 2015, p. 105). At the same time, the complexity of the software systems is dramatically increasing (Manyika et al., 2015, p. 6) and technological advances will only be possible through "[…] synergetic activities conducted in different fields of knowledge, such as telecommunications, informatics, electronics and social science" (Atzori et al., 2010, p. 2878). Thus, it is increasingly important for the software area to lift synergies to develop IoT-related software since the trajectory of IoT is predicted to be as drastic as the development of the software industry in the 1990s (Iyer, 2016).

Both the qualitative and quantitative study revealed a positive impact of **technology turbulence** towards the intended application of innovation fields for lifting synergies. In a turbulent and complex environment, synergetic behavior and the autonomy to choose where to search for new knowledge and which partnerships to follow are

---

[27] The Internet of Things is defined as "sensors and actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines"(Manyika et al., 2015, p. 1).

crucial (Persaud, 2005, p. 423). Furthermore, a study by Candi et al. (2015) revealed a positive influence of technological turbulence on planning flexibility (Candi et al., 2013, p. 138). In the context of innovation fields, it can be argued that under technological turbulence, flexible approaches and procedures are needed due to the quickly-changing technological environment (Candi et al., 2013, p. 135). Thus, innovation fields can be used for the immediate shift of resources from one topic to another.

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P4a	*Exploration has a positive impact on the intended innovation field application for lifting synergies.*
P4b	*Technology turbulence has a positive impact on the intended innovation field application for lifting synergies.*

Table 45: Propositions for the Intended Application of Innovation Fields for Lifting Synergies

Notes:
Source: own representation

6.1.5 Intended Application of Innovation Fields for Technology Intelligence

The synthesized results for the application of innovation fields for technology intelligence show effects for (1) customer orientation, technology orientation, exploration, (2) formalization, centralization as well as (3) market and technology turbulence and competitive intensity. Only 5% of respondents state the intended application of innovation fields for technology intelligence as the potential main type of application, while about half of the respondents did not mention it as an application type. This indicates that the intended usage of innovation fields for technology intelligence is a specialized application. Figure 61 shows the synthesized results.

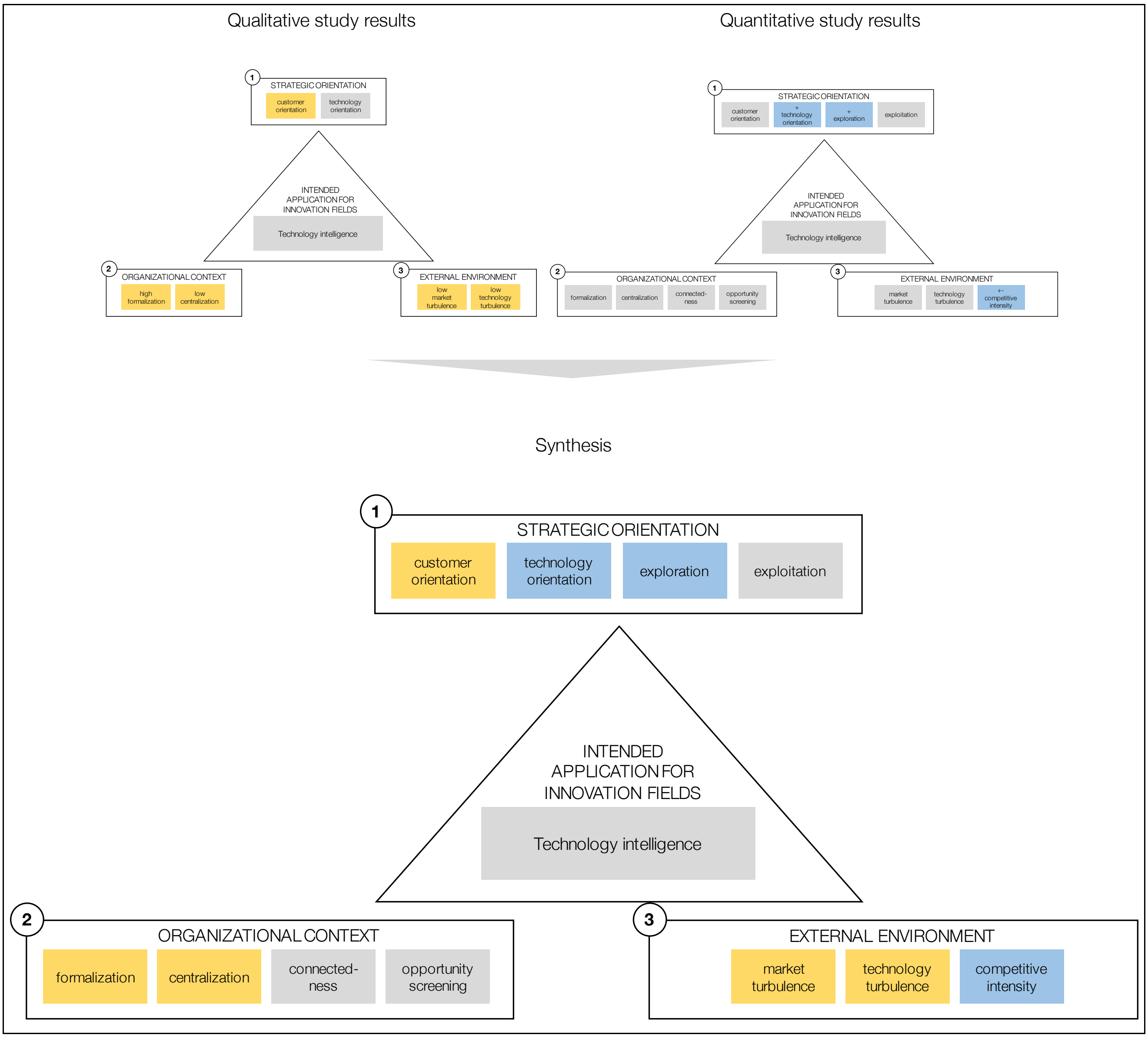


Figure 61: Synthesized Results for Intended Application of IF for Technology Intelligence

Notes:
Source: own representation
Color code: **yellow** = effect from qualitative study; **blue** = effect from quantitative study; **green** = consistent effect in quantitative and qualitative study; **orange** = consistent effect in qualitative and quantitative study, but different effect direction
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

Interestingly, the qualitative study revealed **technology orientation** as an indicator for innovation field application for technology intelligence, while the quantitative study showed **customer orientation** as an influencing factor. Customer orientation is linked to active market search and monitoring for the discovery of new ideas, explaining the connection to innovation field application for technology intelligence (Baker & Sinkula, 2007, p. 329). On the other hand, technology orientation is primarily associated with an internal focus and the acquisition of technological knowledge and the application of this knowledge in customer-centric solutions (Spanjol et al., 2011, p. 238). As indicated by Gatignon and Xuereb (1997), a technology orientation does not exclude an outward orientation (Gatignon & Xuereb, 1997, p. 78). "For example, businesses that search for customer needs to which emergent technologies can be applied are considered both technology- and customer-oriented, at least in terms of a specific technology at a specific time" (Spanjol et al., 2011, p. 238). Spanjol et al. (2011) highlight a negative relationship between technology orientation and market search behavior (Spanjol et al., 2011, p. 243). This finding could not be replicated in the quantitative study. The synthesized results indicate that both a customer and technology orientation influence the intended application of innovation fields for technology intelligence. Although unit affiliation only showed a significant effect for Unit 2: Software Systems, it can be argued that the affiliation to either the system or the technology research area might influence the way of working habit and strategic orientation. Units that seek use cases for novel technologies might be oriented towards both customers and technology. This finding could not be replicated in the quantitative study, showing only a significant effect for technology orientation.

Exploration is found to have a positive impact on innovation field application for technology intelligence. The systematic search for weak signals might be more relevant in an explorative context. Weak signals are especially needed when new information needs to be obtained for product development beyond the current knowledge base. Weak signals can be assigned to the portfolio of innovation fields, ensuring that all employees have the latest information with which to work. Additionally, when competitive intensity rises, exploration is more important to beat competitors to market with new products (Auh & Menguc, 2005, p. 1654). Additionally, a study by Paliokaite and Pacesa (2015) shows that technology intelligence is a measure taken in an explorative setting (Paliokaite & Pačesa, 2015, p. 174).

Organizational Context

No organizational context was found to be significant in the quantitative study. In the qualitative study, low **centralization** and high **formalization** contribute to innovation field application for technology intelligence.

In a study by Kock et al. (2015), a positive influence of formalization on FEI-success could be found (Kock et al., 2015, p. 549). Formalization can provide structure through routine creation and standardization and lessens deviating understandings of identical activities (Auh & Menguc, 2007, p. 1026). Furthermore, formalization increases comparability, which is especially important for the front-end of innovation since ideas and concepts need to be compared and evaluated and decisions have to be made (Martinsuo & Poskela, 2011, p. 904; Montoya-Weiss &

O'Driscoll, 2000, p. 160). On the other hand, with low centralization, the entrepreneurial spirit is encouraged, leading to a higher probability of finding better ideas. (Atuahene-Gima, 2003, p. 365; Kock et al., 2015, p. 544). Kock et al. (2015) discovered that autonomy positively influences FEI success positively (Kock et al., 2015, p. 549). The front-end of innovation is about starting innovation, and low centralization is said to support the initiation of innovation activities and generating new ideas (Auh & Menguc, 2007, p. 1025). Furthermore, there has been empirical evidence that low centralization and high formalization constitute a very favorable setting. Low centralization encourages autonomy and involvement while averting a narrowing bureaucratic structure. Sufficient freedom is provided for the discovery of weak signals, while the formalization ensures no loss of control due to the established systematics for the processing technology intelligence (Auh & Menguc, 2007, p. 1026; Lin & Germain, 2003, p. 1136).

Interestingly, a positive relationship for **opportunity screening** would have been expected, since innovation field application for technology intelligence indicates the active search and distribution of information leading to new innovation activities.

Notably, the qualitative study showed a link between the intended application of innovation fields for technology intelligence and intended application for strategic purposes. All respondents claiming to use innovation fields for technology intelligence were part of the technology research area. As outlined in Chapter 4.4.1.2, the technology research area mainly discovers novel technologies and seeks potential use cases for those. Therefore, innovation fields might help to give structure by (1) linking weak signals to existing innovation fields and (2) giving some indication for possible future search directions. Employees working in the technology research area can then manifest their technologies into innovation fields, link according weak signals and obtain feedback from their customers on their technology intelligence. Furthermore, they can monitor upcoming technologies and manifest them as strategic search directions for potential new innovation opportunities.

Furthermore, a significant effect for **unit affiliation** could be obtained by the quantitative study. Unit 2: Software Systems significantly differs from other units regarding the intended application of innovation fields for technology intelligence. This is consistent with the results from the qualitative study, where only one department belonging to Unit 2 declared technology intelligence as an application of secondary importance. As outlined earlier, the working habits of software engineers might diverge from other research areas, thus explaining this finding.

External Environment

Competitive intensity shows an inverse U-shaped relationship towards the intended application of innovation fields for technology intelligence. As previously mentioned, the adaptability to the environment has to increase to shift activities when competitive intensity rises, making innovation fields a less relevant topic, aiming rather towards imitation or cost reduction (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723). On the other hand, Zahra (1993) states that under high competition, the requirement for differentiation from the competition rises, making innovation fields for technology intelligence an instrument for the systematic discovery of new advancements and weak signals ultimately leading to new ideas and concepts (Auh & Menguc, 2005, p.

1654; Zahra, 1993, p. 324). In an explorative setting under high competitive intensity, innovation fields can help to structure the search for new technologies and cluster collected weak signals in the according fields. Furthermore, innovation fields can be used as a strategic filter for the collection of weak signals and as a constraint to obtain weak signals beyond defined innovation fields.

The intended application of innovation fields for technology intelligence was found to be affected by low **market and technology turbulence** in the qualitative study. Spanjol et al. (2011) found an engagement into active search behavior dependent on high turbulence, contradicting the findings from this study (Spanjol et al., 2011, p. 244). Both findings could not be validated in the quantitative study. As outlined in Chapter 4.4.1.2, the intended application of innovation fields for technology intelligence seemed relevant for Unit 6: Manufacturing Technologies. At the time of the study, no technological turbulences could be detected, while substantial progress in some of the research projects could be achieved. This indicates that Unit 6 found itself in a situation of competitive advantage, temporarily dominating technological advancements, supporting the perceived low turbulence. The quantitative study did not replicate this finding.

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P5a	*Exploration is positively related to the intended innovation field application for technology intelligence.*
P5b	*Technology orientation is positively related to the intended innovation field application for technology intelligence.*
P5c	*Competitive intensity has an inverse U-shaped effect on the intended application of innovation fields for technology intelligence.*

Table 46: Propositions for the Intended Application of Innovation Fields for Technology Intelligence

Notes:
Source: own representation

6.1.6 Intended Application of Innovation Fields for Portfolio Extension

Portfolio extension was only mentioned as an application of secondary importance in the qualitative study. Therefore, no distinctive contextual factors from the qualitative study could be obtained. The quantitative results for the intended application of innovation fields for portfolio extension show effects for (1) technology orientation, (3) technology turbulence and competitive intensity. Organizational context shows no influence on the intended application of innovation fields for portfolio extension. Only 1% of the respondents state the application of innovation fields for portfolio extension as the potential main type of application, while about two-thirds of the respondents (63.0%) did not mention it as the intended type of application. This indicates that the intended application of innovation fields for portfolio extension is a specialized type of application with low intention to use. Figure 62 shows the quantitative results.

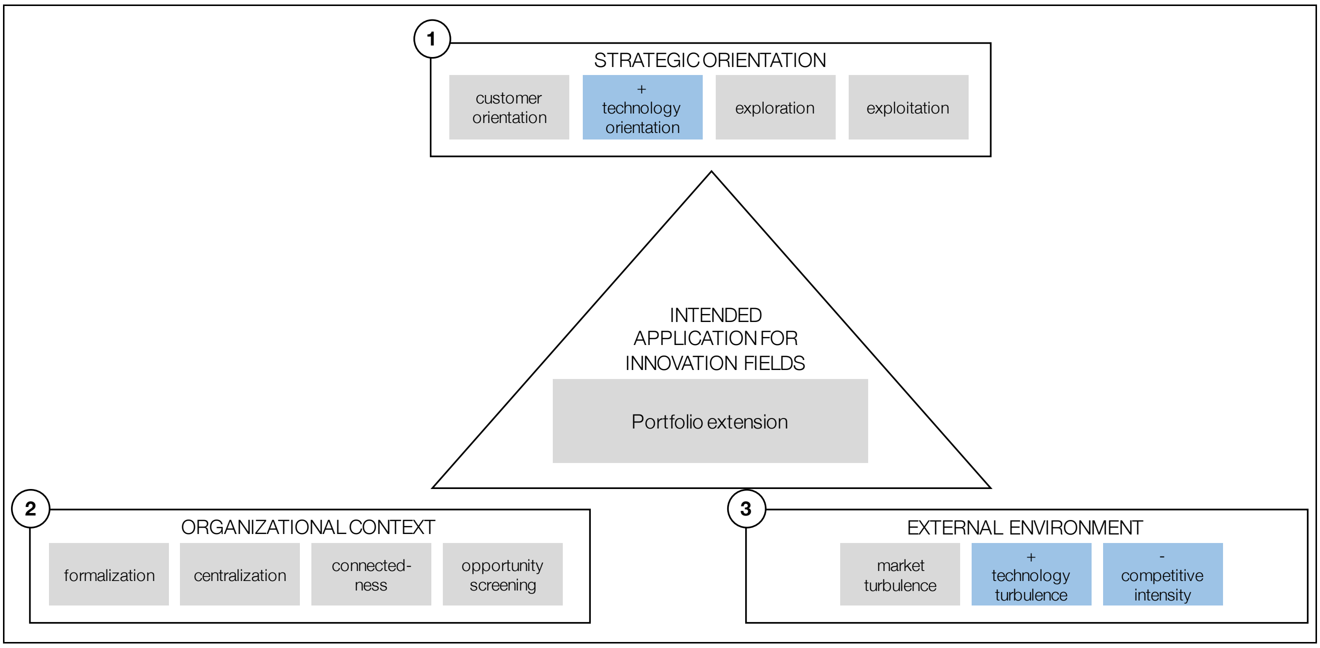


Figure 62: Synthesized Results for Intended Application of Innovation Fields for Portfolio Extension

Notes:
Source: own representation
Color code: **blue** = significant effect
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

Technology orientation has been found to have a positive connection towards the intended application of innovation fields for portfolio extension. In a study by Zhou et al. (2005), a positive connection is found between technology orientation and technology-based radical innovation (Zheng et al., 2005). Portfolio extension often implies the emergence of radical innovation, regarding missing fit and familiarity from the perspective of the organization. Thus, the intended application of innovation fields for portfolio extension involves the discovery of radical innovation, as described in Chapter 2.2.2. Technology orientation leads to greater resource commitment to study novel technologies and apply them to new products. This is especially true in an R&D setting. Furthermore, an emphasis is placed on creativity and ideation in a technology-oriented environment, "encourage[ing] employees with 'crazy ideas' or an instinctive interest in inventing something drastically new" (Zheng et al., 2005, p. 46). Furthermore, it is said that technology orientation is more open to the proactive search for new products and "less bound by the reactive nature of customer and competitor orientations […] [and] less likely to restrict their innovation efforts to already existing product categories" (Spanjol et al., 2011, p. 239). Additionally, technology orientation has a positive connection to idea novelty, indicating that technology orientation encourages the search for ideas outside of the existing portfolio and more radical ideas. Thus, this finding is in line with existing literature (Spanjol et al., 2011, p. 243). Gatignon and Xuereb (1997) show that the radicalness of products and dissimilarity with existing products on the markets is highest under high technological orientation, supporting the finding that technology orientation influences innovation field application for portfolio extension (Gatignon & Xuereb, 1997, p. 86). Additionally, Zhou et al. (2005) argue that a more customer-oriented environment might oversee technological advances and primarily focus on existing and current customers, neglecting strategic innovation projects for sustainable competitive advantage (Slater & Narver, 1998, p. 67; Zheng et al., 2005, p. 45).

A positive effect for **exploration** was expected, since it is defined as the search for new products and technologies, thereby enhancing the existing knowledge of the organization (Greve, 2007, p. 945; March, 1991, p. 71). For the intended application of innovation fields for portfolio extension, an explorative setting is inherent to the nature of the activity, although it could not be shown by the study results.

Organizational Context

No factors for **organizational context** were found to be significant in the quantitative study.

It would be expected to find a negative influence of **formalization** on innovation field application for portfolio extension given that ideas that are beyond the scope of the organization have a higher risk of being filtered out in formalized innovation processes (Bonner et al., 2002, p. 237; Kock et al., 2015, p. 544; Sethi & Iqbal, 2008, p. 127).

Furthermore, positive effects for **opportunity screening** would have been expected, since the discovery of new segments requires the active search and distribution of information leading to new ideas.

Similar to innovation field application for lifting synergies, a positive influence of **connectedness** on innovation field application for portfolio extension would have been expected. When planning to extend the current portfolio, it is crucial to connect to different knowledge domains (Poetz & Prügl, 2010, p. 900). In this regard, innovation fields are an instrument for the collaborative understanding and definition of potential new segments, communication and knowledge transfer (Gillier et al., 2010, p. 894; Hatchuel et al., 2001, p. 12).

A positive effect between **job tenure** and the intended application of innovation fields for portfolio extension was revealed. In a study by Kimberly and Evanisko (1981), it was shown that there is a relationship between job tenure and adoption of technological innovation in hospitals (Kimberly & Evanisko, 1981, p. 702). One argumentation for this finding is as follows: "longevity in the job is a surrogate for systematic legitimacy and for knowledge of how to navigate the political waters in order to obtain desired outcomes" (Kimberly & Evanisko, 1981, p. 697). Although this study is only considered executives and the effect on technology adoption rates, a similar argumentation can be followed for the innovation field context. Associates with a higher job tenure know the organization well and know what works best to work efficiently in the setting of the organization. Given their experience, they still appreciate some guidance for future directions and new segments. Especially in the R&D setting, employees have more leeway in their project choice and development, which is even more evident in the front-end of innovation and guidance regarding what future directions can be pursued.

External Environment

Competitive intensity is shown to negatively influence the intended application of innovation fields for portfolio extension. When a company faces strong competitive intensity, there is a multitude of solutions on the market for the customer's choosing and prices are likely to decrease, starting a price war between the competitors. Since innovation is a cost-intensive endeavor, firms will start imitating what the competitors are doing, neglecting technological advancements (Zheng et al., 2005, p. 47). This could be shown in the study of Zhou et al. (2005) with Chinese companies (Zheng et al., 2005, p. 52). Interestingly, for all other applications, an inverse U-shaped relationship for competitive intensity could be detected.

Technology turbulence was found to have a positive impact on innovation field application for portfolio extension. A study from Zhou et al. (2005) could show a positive impact of technology turbulence on technology-based innovation (Zheng et al., 2005, p. 51). Under turbulent conditions, R&D cycles decrease, thus diminishing competitive advantage, while the need to invest into technological advancements increases, preventing being "squeezed from the market" (Zheng et al., 2005, p. 47). This explains the intended application of innovation fields for portfolio extension under high turbulence.

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P6a	*Technology orientation has a positive impact on the intended innovation field application for portfolio extension.*
P6b	*Technology turbulence has a positive impact on the intended innovation field application for portfolio extension.*
P6c	*Competitive intensity is negatively related to the intended innovation field application for portfolio extension.*

Table 47: Propositions for the Intended Application of Innovation Fields for Portfolio Extension

Notes:
Source: own representation

6.2 Discussion of Innovation Field Proficiency

The next chapters discuss the synthesized findings from the qualitative and quantitative study for the perceived proficiency of innovation fields, namely perceived usefulness, innovation fields enhancing performance and innovation fields enhancing innovativeness. Each chapter is subdivided into the contextual factors strategic orientation, organizational context, and external environment and finishes with propositions derived from the discussion.

6.2.1 Perceived Usefulness of Innovation Fields

The perceived usefulness of innovation fields is the first of three proficiency-related variables. Given that these variables were only measured in the quantitative study, therefore, no distinctive contextual factors from the qualitative study could be obtained. The quantitative results for perceived usefulness of innovation fields show effects for (1) customer orientation, exploration, and (3) market turbulence. Organizational context showed only non-significant influence on the perceived usefulness of innovation fields. Figure 63 shows the quantitative results.

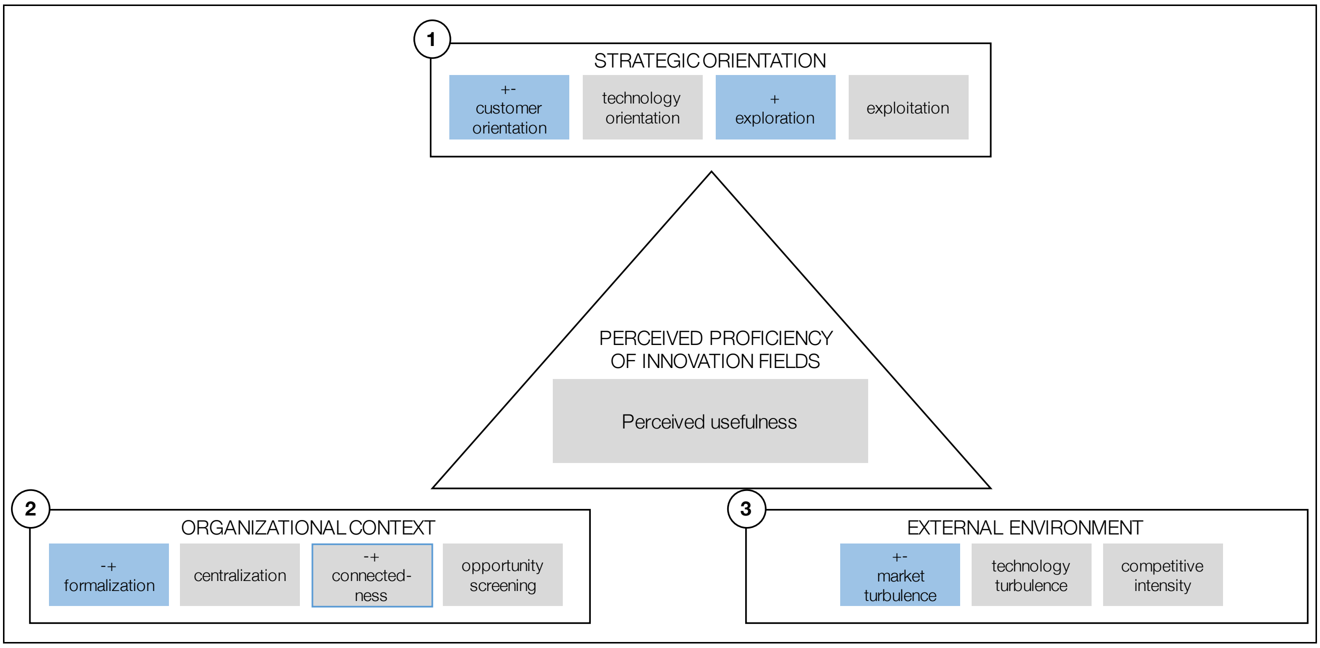


Figure 63: Synthesized Results for Perceived Usefulness of Innovation Fields

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

An inverse U-shaped relationship of **customer orientation** was detected towards the perceived usefulness of innovation fields. Durmusoglu and Barczak (2011) found evidence that the use of secondary data (e.g., stored information about trends, competitor landscape, and customer requirements) in the front-end of innovation and during discovery phase has a positive effect on product performance. For their study, they examined specifically the use of IT tools in the front-end of innovation such as online information systems. As explained in Chapter 3.4.2, innovation fields are stored in an online information system for innovation management and connected, to e.g.

scientific partnerships, ideas, weak signals, and innovation projects. Thus, customer orientation fosters the perceived usefulness of innovation fields through the emergent need to store data, leading to greater overall performance (Durmusoglu & Barczak, 2011, p. 327). A very high customer orientation has a reverse effect on the perceived usefulness of innovation fields. As mentioned in the qualitative study, with a very high customer orientation, innovation fields might not be needed since the customers will articulate their needs and wishes very precisely.

A positive effect for **exploration** has been detected towards the perceived usefulness of innovation fields. For building up new knowledge, it is crucial to integrate knowledge from different knowledge domains (Poetz & Prügl, 2010, p. 900). In this context, innovation fields can help as an instrument for a common understanding and definition of the topics in question, opting as a means of communication and knowledge transfer and thus explaining the perceived usefulness of innovation fields (Gillier et al., 2010, p. 894; Hatchuel et al., 2001, p. 12).

Organizational Context

No significant effects for organizational context could be obtained from the quantitative study. However, two effects were discovered that were non-significant but part of the regression model, namely connectedness and formalization.

The model shows a non-significant U-shaped relationship for **connectedness**. It would have been expected to find a positive relationship for connectedness, since prior studies, such as De Luca et al. (2010) show that internal coordination has a positive impact on effectiveness (Luca et al., 2010, p. 308).

A U-shaped impact of **formalization** on the perceived usefulness of innovation fields was detected. This finding has to be interpreted with caution since only the quadratic term showed significance in the quantitative study. In low- to medium-formalized climates, innovation fields are perceived as less useful, while with very high levels of formalization the perceived usefulness increases. There are ambiguous results about the type of impact of formalization in the context of innovation. In a study by Kock, Heising & Gemünden (2015), it was shown that process formalization has a positive impact on innovation fields (Kock et al., 2015, p. 549). Formalization can provide a structure through routine creation and standardization and lessens deviating understandings of identical activities (Auh & Menguc, 2007, p. 1026). Furthermore, formalization increases comparability, which is of particular importance for the front-end of innovation, since ideas and concepts need to be compared and evaluated (Martinsuo & Poskela, 2011, p. 904; Montoya-Weiss & O'Driscoll, 2000, p. 160). Equal standards for all ideas support efficient, transparent and fair assessments of ideas and concepts in the front-end of innovation (Cooper, 2008, p. 221; Kock et al., 2015, p. 544). In the context of perceived usefulness of innovation fields, they are seen as more beneficial in a more formalized surrounding.

External Environment

An inverse U-shaped relationship for **market turbulence** has been found for the perceived usefulness of innovation. With increasing levels of market turbulence, uncertainty reduction is increasingly important, making guiding directions through innovation fields in the front-end of innovation an important instrument for success (Gatignon &

Xuereb, 1997, p. 87). On the other hand, when market turbulence is too high, the usefulness of innovation fields decreases and activities might be shifted away from innovation, thus weakening the perceived usefulness of innovation fields.

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P7a	*Customer orientation has an inverse U-shaped effect on the perceived usefulness of innovation fields.*
P7b	*Exploration is positively related to the perceived usefulness of innovation fields.*
P7c	*Market turbulence has an inverse U-shaped effect on the perceived usefulness of innovation fields.*

Table 48: Propositions for the Perceived Usefulness of Innovation Fields

Notes:
Source: own representation

6.2.2 Innovation Fields Enhancing Performance

Innovation fields enhancing performance was only measured in the quantitative study. Therefore, no distinctive contextual factors from the qualitative study could be obtained.

The quantitative results for innovation fields enhancing performance show effects for (1) customer orientation as well as (3) technology turbulence and competitive intensity. The organizational context showed no significant influence on innovation fields enhancing performance. Figure 64 shows the quantitative results.

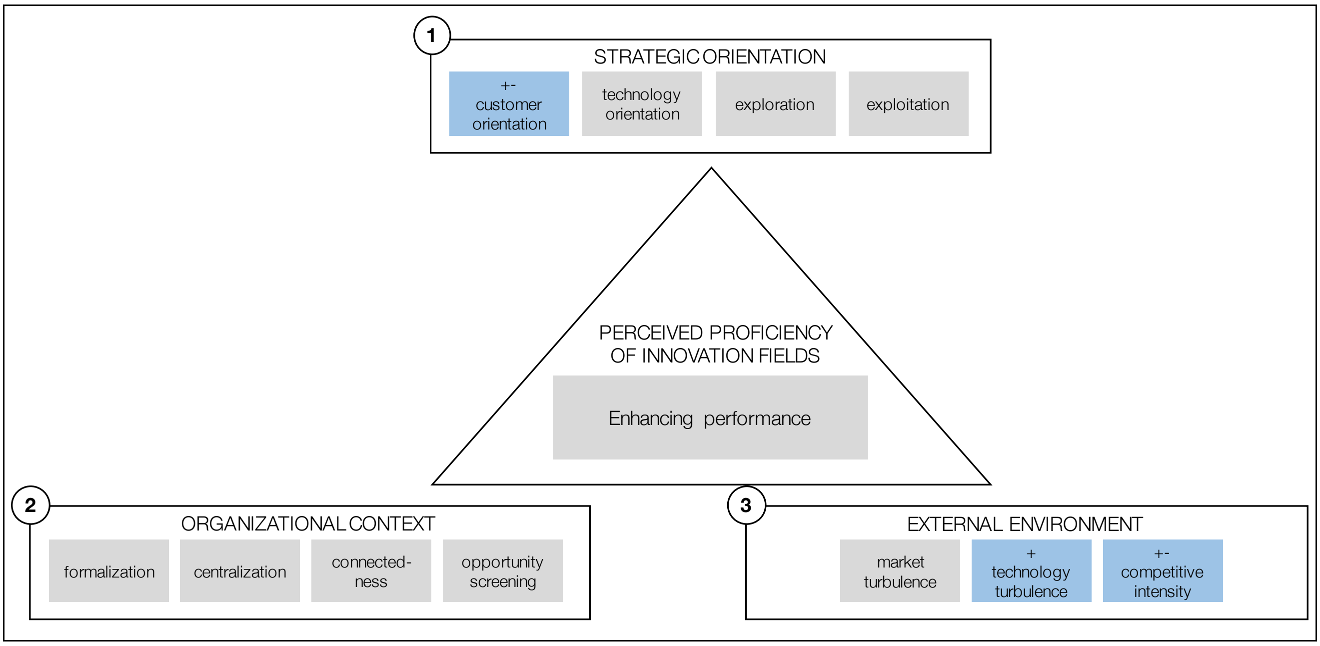


Figure 64: Synthesized Results for Innovation Fields Enhancing Performance

Notes:
Source: own representation
Color code: **blue** = significant effect,
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

An inverse U-shaped relationship between **customer orientation** and innovation fields enhancing performance could be obtained. Several studies tested that customer orientation positively influences performance (Baker & Sinkula, 2007, p. 329; C. H. Noble & Mokwa, 1999, p. 57; Spanjol et al., 2011, p. 237; Zheng et al., 2005, p. 52). This performance is mostly achieved through greater innovativeness, especially for technology-based innovation (Zheng et al., 2005, p. 52). Innovation fields can help to store relevant customer data and trends, enhancing the performance (Durmusoglu & Barczak, 2011, p. 327). Thus, in a customer-oriented setting, innovation fields are seen as supportive for achieving greater overall performance. On the other hand, a high level of customer orientation might render the application of innovation fields obsolete, since customers express their needs and demands precisely. Especially in a B-2-B context with OEMs, the strategy is often determined through the OEM (Schiele, 2006, p. 927). The sole reliance on customers can lead to a lack of innovativeness and in turn, performance, thus explaining the negative effect at very high customer orientation levels (Bower & Christensen, 1995, p. 45; Racela, 2014, p. 19).

Organizational Context

No influencing factors for **organizational context** were discovered for innovation fields enhancing performance.

External Environment

Competitive intensity shows an inverse U-shaped effect for innovation fields enhancing performance. This finding is in line with studies showing that in the case of rising competitive intensity, performance is raised through a greater emphasis on innovation activities to keep up with the competition. On the other hand, with very high levels of competitive intensity, resources are shifted towards imitation or cost-reduction, superseding innovation fields and ultimately reducing performance (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723).

A positive connection between **technology turbulence** and the perceived performance of innovation fields was found. Li and Atuahene-Gima (2001) find evidence for enhanced performance when using a defined innovation strategy, especially under high turbulence. This is due to the fact that a greater focus leads to achieving superior innovation during turbulent times (Li & Atuahene-Gima, 2001, p. 1128). In the context of innovation fields, it can be argued that under technology turbulence, the perceived performance achieved through using innovation fields rises due to the increased need for sustained innovation, which can be enforced through innovation fields.

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P9a	*Customer orientation has an inverse U-shaped effect on innovation fields enhancing performance.*
P9b	*Technology turbulence has a positive effect on innovation fields enhancing performance.*
P9c	*Competitive intensity has an inverse U-shaped effect on innovation fields enhancing performance.*

Table 49: Propositions for Innovation Fields Enhancing Performance

Notes:
Source: own representation

6.2.3 Innovation Fields Enhancing Innovativeness

A study by Salomo et al. (2008) showed a positive influence of innovation field orientation on innovativeness. Using innovation fields enhances transparency, thereby consolidating similar innovation activities and revealing gaps for future opportunities (Salomo et al., 2008, p. 564). This study sheds light on what the contextual factors are for innovation fields enhancing innovativeness.

Contextual factors for Innovation fields enhancing innovativeness were only captured in the quantitative study. Therefore, no distinctive contextual factors from the qualitative study could be obtained.

The quantitative results for innovation fields enhancing innovativeness show effects for (3) technology turbulence and competitive intensity. Strategic orientation and organizational context showed only non-significant influence on innovation fields enhancing innovativeness. Figure 65 shows the quantitative results.

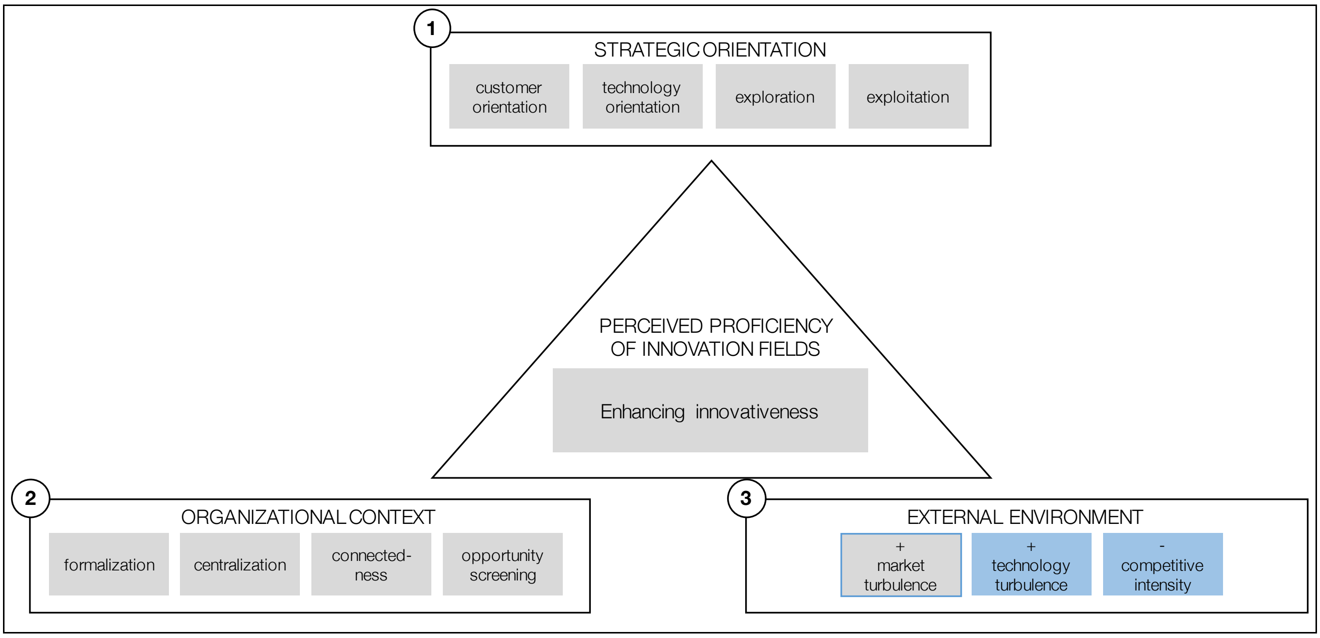


Figure 65: Synthesized Results for Innovation Fields Enhancing Innovativeness

Notes:
Source: own representation
Color code: **blue** = significant effect, **blue frame** = effect in the model specification, but not significant
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

No influencing factors for strategic orientation could be obtained from the regression model. Interestingly, both **customer and technology orientation** are said to be positively associated with innovativeness by concentrating on either customer needs or using the right resources (Baker & Sinkula, 2007, p. 328; Gatignon & Xuereb, 1997, p. 87; Paladino, 2007, p. 548; Spanjol et al., 2011, p. 237). Thus, effects for these orientations would have been expected. For the context of innovation fields, strategic orientations do not influence a perceived increase of innovativeness through innovation fields. Moreover, the results indicate a stronger influence of environmental factors.

Organizational Context

No influencing factors for **organizational context** were discovered for innovation fields enhancing innovativeness.

External Environment

Competitive intensity has a negative impact on the perceived innovativeness of innovation fields. This finding is in line with existing studies, suggesting a negative relationship between competitive intensity and innovativeness (Baker & Sinkula, 2007, p. 326; Tsai & Yang, 2013, p. 1287). It is argued that in fierce competition, potential innovation benefits or technological advantages might be reduced (Tsai & Yang, 2013, p. 1287).

Technology turbulence has a positive impact on perceived innovativeness. The more turbulent the environment, the more likely that innovation fields are perceived as enhancing innovativeness. Technology turbulence is also an influencing factor for innovation field application for lifting synergies and portfolio extension. Both models require building up new knowledge and the set-up of new information sources to develop new segments. When the search scope widens, the potential to find more innovative ideas increases (Candi et al., 2013, p. 135; Katila & Ahuja, 2002, p. 1191). Furthermore, technology turbulence requires the usage of latest technology to achieve competitive advantages (Tuominen, Rajala, & Möller, 2004, p. 505). Additionally, a study by Calantone et al. (2003) suggests that under high technological turbulence, strategic planning for innovation holds special importance to sustain innovativeness. In order to plan effectively, it is required to integrate key stakeholders from the company into the planning process. With innovation fields, this requirement can be met, using them as an instrument for the collaborative manifestation of the innovation strategy (Calantone et al., 2003, p. 93). This study also suggests the importance of **connectedness** to reach the state of innovativeness through corporate planning. However, the quantitative study did not show any relationship between connectedness and perceived innovativeness.

Tsai and Yang (2013) also detected a positive relationship between **market turbulence** and innovativeness. Under high market turbulence, evolving needs can only be met with corporate innovativeness (Tsai & Yang, 2013, p. 1282). Thus, market turbulence would also have been an expected effect. Market turbulence was found to be part of the model specification, but not significant.

Propositions

From the discussion above, the following propositions can be made:

No	Proposition
P8a	*Technology turbulence has a positive impact on innovation fields enhancing innovativeness.*
P8b	*Competitive intensity has a negative impact on innovation fields enhancing innovativeness.*

Table 50: Propositions for Innovation Fields Enhancing Innovativeness

Notes:
Source: own representation

6.3 Discussion of Overall Findings

After discussing each of the intended innovation field applications and their perceived proficiency considering their contextual factors, this chapter summarizes the overall implications that can be drawn. Table 51 summarizes the effects found in both the qualitative and quantitative study.

	Independent/Dependent variables	Intention to use	Strategic purposes	Ideation	Lifting synergies	Tech. Intelligence	Portfolio extension	Perc. usefulness	Enhance performance	Enhance innovativeness
Strategic orientation	Cust. orientation	Qual: **high** Quan: **+-**	Quan: **+-**			Qual: **high**		Quan: **+-**	Quan: **+-**	
	Tech. orientation				Qual: **high**	Quan: **+**	Quan: **+**			
	Exploration				Quan: **+**	Quan: **+**		Quan: **+**		
	Exploitation			Quan: **+**						
Organizational context	Formalization	Qual: **high** Quan: **-**	Qual: **high** Quan: **-**		Qual: **high**	Qual: **high**		Quan: **-+**		
	Centralization	Qual: **high**		Quan: **+**		Qual: **low**				
	Connectedness		Quan: **-+**							
	Opp. screening									
External environment	Market turbulence		Qual: **low**	Quan: **+-**	Qual: **low**	Qual: **low**		Quan: **+-**		
	Tech. turbulence	Qual: **high**	Qual: **high**		Qual: **high** Quan: **+**	Qual: **low**	Quan: **+**		Quan: **+**	Quan: **+**
	Comp. intensity	Quan: **+-**	Quan: **+-**	Quan: **+-**		Quan: **+-**	Quan: **-**		Quan: **+-**	Quan: **-**
Controls	Process satisfaction	Quan: **+**	Quan: **+**	Quan: **+**	Quan: **+**	Quan: **+**	Quan: **+**	Quan: **+**	Quan: **+**	Quan: **+**
	Unit 2: Software S.			Quan: **-**	Quan: **-**	Quan: **-**	Quan: **-**	Quan: **-**	Quan: **-**	Quan: **-**
	Man. responsibility		Quan: -		Quan: **-**	Quan: **-**	Quan: **-**	Quan: **-**	Quan: **-**	
	Tenure						Quan: +			

Table 51: Overview of Synthesized Findings from the Qualitative and Quantitative Study

Notes:
Source: own representation
Color code: **yellow** = qualitative study, **blue** = quantitative study, **green** = effect in qualitative and quantitative study, **orange** = consistent effect in qualitative and quantitative study, but different effect direction
+ = linear positive effect, - = linear negative effect, +- = inverse U-shaped effect -+ = U-shaped effect

Strategic Orientation

Comparing all influencing factors subsumed in strategic orientation, customer orientation shows the greatest impact in terms of the number of regression models with a significant effect. Predominantly, customer orientation shows an inverse U-shaped effect, implying that customer orientation might be an indicator for the likeliness of applying innovation fields, but only in the case of low to moderate customer orientation. Customer orientation is a good indicator for innovation field application if orientation is not customer-led (Slater & Narver, 1998). Being customer-led implies that the organization focuses primarily on customer needs, not taking other factors into account. In these cases, innovation activities will be started, once customers express their requirements and activities are not aligned according to ambidextrous adaptation. As outlined in the previous chapters, under high customer orientation, innovation fields will not be perceived as useful since guidelines, requirements, and needs are derived primarily by the customer itself. Thus, under moderate levels of customer orientation, the organization possess the flexibility to adjust innovation activities towards customer needs as well as other factors such as the balance between exploration and exploitation.

Technology orientation shows a positive impact for the intended application of innovation fields for technology intelligence, and portfolio extension and was reported high for lifting synergies in the qualitative study. At the R&D division, both technology intelligence and portfolio extension are likely technology-driven, while lifting synergies is also primarily derived from a technology perspective. Interestingly, while the qualitative study revealed high customer orientation as influencing factor for technology intelligence, the quantitative study shows a significant effect for technology orientation. As outlined in Chapter 6.1.5, both orientations might be viable in an R&D setting, especially when searching for use cases for new technologies.

Exploration shows a significant positive effect in three models (lifting synergies, technology intelligence and perceived usefulness). Innovation fields are perceived as useful with an explorative orientation since innovation fields can be used to clearly communicate the explorative setting and to redefine search boundaries (Gillier et al., 2010, p. 894; Hatchuel et al., 2001, p. 12). Employees thus get transparency and a clear understanding of the new search directions. Furthermore, with an explorative orientation, innovation fields support common understanding and communication, especially when monitoring technologies or requiring additional knowledge by other research units or external partners.

Interestingly, exploitation only shows a significant positive effect for innovation field application for ideation. This implies that exploitative orientation has a minor impact on innovation field application. Employees usually know how to incrementally improve products or technologies, rendering innovation fields obsolete. On the other hand, for ideation, innovation fields might be useful for systematic idea generation and refining knowledge more profoundly through the combination of existing solutions (Katila & Ahuja, 2002, p. 1191; Levinthal & March, 1981, p. 311).

To summarize, customer orientation and exploration are the main indicators for intended innovation field application and proficiency from the perspective of strategic orientation.

Organizational Context

From the qualitative study, it could be obtained that both centralization and formalization play a crucial role in determining the types of applications for innovation fields. The quantitative study could not bolster this. From an organizational context perspective, formalization is only significant in two models (general intention, strategic purposes), while centralization is only significant for innovation field application for ideation. Furthermore, the findings for formalization show contradicting effect directions in the comparison of the qualitative and quantitative study.

Formalization has a negative impact on both the general intention to use innovation fields and the intended application of innovation fields for strategic purposes. All qualitative results imply a positive impact of formalization on innovation field application. The degree of formalization and its perception remains a debated topic and a double-edged sword. Depending on the individual perception of formalization, innovation fields as structuring element of the strategic phase of the front-end of innovation are either appreciated as valuable support in discovering and elaborating on innovation or perceived as innovation inhibitor, limiting the freedom of search. The qualitative study could only obtain insights of individual perceptions of formalization that are not generalizable in this context, explaining the contradiction.

Centralization only shows a positive impact for innovation field application for ideation in the quantitative study. Qualitative results reveal intended application of innovation fields for technology intelligence under low centralization. When performing ideation, a high number of ideas emerges that need to be filtered and evaluated accordingly. Centralization supports quick decision-making since information is consolidated (Auh & Menguc, 2007, p. 1025).

Both connectedness and opportunity screening were expected to influence intended innovation field application and perceived proficiency, but were not found to be significant in the study. Connectedness only had a significant effect on the innovation field application for strategic purposes. For this type of application, communication and inter-functional connectedness are key to distribute the innovation strategy throughout the whole organization and in order to make sure that the innovation strategy is commonly understood (Crawford, 1980, p. 11; Salomo et al., 2008, p. 561). It seems that the intended application of innovation fields for strategic purposes is the most prevalent application, where the degree of connectedness is of the essence.

Opportunity screening, on the other hand, was not found significant for either the intended application of innovation fields or perceived proficiency. Although the qualitative study found evidence that opportunity screening might indicate influence of the working habit towards the application of innovation fields, this factor did not yield any results. Opportunity screening is defined as active search behavior and the generation of intelligence and their sharing (Hüsig et al., 2005, p. 861; Jaworski & Kohli, 1993, p. 56; Zaltman et al., 1973, p. 62). It might be that the way of working itself has no impact on intended innovation field application and perceived proficiency per se but can only be seen through the strategic orientation. Otherwise, the factor might not have been described sufficiently to capture the notion of the working habit in the R&D setting.

Overall, organizational context only plays a minor role in explaining innovation field application and perceived proficiency, which needs further investigation. It seems that either organizational factors, in fact, do not influence the application of innovation fields or that other organizational factors influencing the intended application have not been discovered and examined.

Although research suggests that the organizational context holds strong importance to foster ambidexterity (Argote & Miron-Spektor, 2011, p. 1125; Gibson & Birkinshaw, 2004, p. 212; Raisch & Birkinshaw, 2008, p. 391), the study results remain inconclusive regarding this contextual factor.

External Environment

The findings suggest that the external environment has a strong influence on intended innovation fields application and perceived proficiency. Competitive intensity is a significant factor for almost all models, with a negative influence or an inverse U-shaped effect, implicating that a moderate competitive environments positively influences innovation field application. As outlined in previous chapters, the adaptability to the environment has to increase in order to shift activities when competitive intensity rises, making innovation fields a less relevant topic, aiming rather towards imitation or cost reduction (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723). On the other hand, Zahra (1993) states that under high competition, the requirement for differentiation from the competition rises, making innovation fields an instrument for the systematic discovery of new advancements, despite high competitive intensity (Auh & Menguc, 2005, p. 1654; Zahra, 1993, p. 324).

Market turbulence shows an inverse U-shaped relationship for ideation and perceived usefulness, while the qualitative study implied the application of innovation fields for strategic purposes, lifting synergies and technological intelligence under low market turbulence. Both studies show the same effect direction. Similarly to competitive intensity, it can be argued that high levels of market turbulence lead to the need for uncertainty reduction, ultimately shifting resources away from innovation and towards cost-reduction and short-term solutions (Gatignon & Xuereb, 1997, p. 87).

Technology turbulence shows a positive impact on innovation field application for lifting synergies and portfolio extension, while the qualitative study shows effects for general intention to use, strategic purposes and technology intelligence under high technological turbulence. In a setting with high technological turbulence, the environment gets more complex and the need for synergies increases (Persaud, 2005, p. 423). Generally, technological turbulence diminishes competitive advantage, increasing the need to invest in innovation activities (Zheng et al., 2005, p. 47). Furthermore, technological turbulence enhances planning flexibility (Candi et al., 2013, p. 138). In the context of innovation fields, it can be argued that under technological turbulence, flexible approaches and procedures are needed, and innovation fields enable the rapid shift of resources. Furthermore, technology turbulence seems to be an important factor for perceived innovation field proficiency, having a positive influence on both innovativeness and performance. Under high technological turbulence, strategic planning for innovation is of special importance to sustain innovativeness (Calantone et al., 2003, p. 93). Innovation fields can be the instrument to guide organizations through turbulent times and to plan effectively.

Overall, for innovation field proficiency, mainly environment variables show significant effects. A study by Poskela and Martinsuo (2009) argues that turbulence reduces the effectiveness of process formalization. In times of high turbulence, more trial and error, iterations and leeway needs to be permitted. In the context of innovation fields and taken together with the overall influence of environmental factors for the application of innovation fields, they might validate the notion of innovation fields being a flexible instrument in the front-end of innovation despite or especially in terms of environmental turbulence (Poskela & Martinsuo, 2009, p. 676).

Control Variables

The findings show three control variables with a strong influence on both intended innovation field applications and perceived proficiency, namely unit affiliation, managerial responsibility, and process satisfaction.

The qualitative study showed differences in the application of innovation fields for the technology and system research area in the corporate R&D division. This finding was not validated by the quantitative study, but it was shown that Unit 2: Software Systems has an overall lower usage level for innovation fields, with the exception of general intention to use innovation fields and the application of innovation fields for strategic purposes. As indicated in Chapter 6.1.4, Unit 2 implemented an adapted their NPD process, granting more autonomy to employees regarding budget allocation for innovation activities. Furthermore, there is an indication that there is an essential difference between software-related projects and other engineering and science projects at the corporate R&D division. As outlined in Chapter 4.4.1.3, scholars have been trying to grasp the differences between software development work and other engineering projects. The main differences cover (1) complexity, (2) flexibility and (3) invisibility. Software projects are described as more complex than other engineering projects due to their dependence on hardware development and since written code is not repeatable (Brooks, 1987, p. 13). Furthermore, unlike finished manufactured projects, software can always be changed and adapted and needs to be maintained accordingly (Brooks, 1987, p. 14). It was argued that the way in which software engineers work differs profoundly from other disciplines and has developed over time. Interestingly, no significant unit factor was found for the models explaining the general intention to use innovation fields and the intended application of innovation fields for strategic purposes. Unit 2 has already implemented a so-called *future radar*, a long-term plan for software activities, which indicates that they might not have seen the need for the definition of additional innovation fields. Furthermore, rejecting innovation fields might have been a sign of rebellion against processes defined by the corporate R&D division, which might not be as applicable to the needs of Unit 2 compared to other units. Finally, as indicated in Chapter 4.4.1.3 and 6.1.4, the tremendous changes in the IT industry might have prevented Unit 2 from using innovation fields.

Managerial responsibility shows a significant negative effect on the application of innovation fields and perceived proficiency throughout the majority of models. While this could simply mean that for managers, innovation fields are less useful due to the distinct knowledge about corporate goals and innovation strategy, another explanation for this finding might be that managers feel offended in their role as executives. In their leadership positions, it is part of their job to steer and guide the front-end of innovation, which might be counteracted through the establishment of innovation fields (Waldman & Bass, 1991, p. 175).

Process satisfaction has a significant positive impact on the application of innovation fields throughout all models. Since innovation fields pose an extension to the existing innovation management process, process satisfaction is an important indicator for the likelihood of engaging with adaptions and adjustments to the established process and needs to be taken into account when implementing or introducing new instruments. The general intention to use innovation fields is thus influenced by the overall satisfaction with the installed NPD process, linking to the perceived proficiency and quality of the processes in place (Hüsig et al., 2005, p. 865). It can be concluded that process satisfaction is a crucial factor to be observed and measured whenever adaptions to established processes are made.

Work tenure has a significant positive effect on innovation field application for portfolio extension. In a study by Kimberly and Evanisko (1981), it was shown that there is a relationship between job tenure and the adoption of technological innovation in hospitals (Kimberly & Evanisko, 1981, p. 702). It is argued that job tenure leads to increased experience on how to work and interact most effectively within the setting of the organization (Kimberly & Evanisko, 1981, p. 697). However, even with long experience, employees appreciate guidance regarding new directions and new segments for the organization. Especially in the R&D setting, employees have more leeway in their project choice and development, especially in the front-end of innovation and guidance regarding what future directions can be pursued.

Age was found to have no influence on either the intended application or perceived proficiency of innovation fields.

Concluding remarks will be made regarding the explanation of the discrepancies between the qualitative and quantitative results. Since this study is of an explorative nature, it could not be ensured that the contextual factors chosen and elaborated are those that have the most influence on the intended application and perceived proficiency of innovation fields. The qualitative study served as an initial indicator for the perceived contextual factors and as preparation for the quantitative study. The qualitative study did not cover the comprehensive picture of the individual perceived contextual factors of employees in the organization, unlike the quantitative study. Thus, inconsistent results are possible in regarding the quantitative study since the perception of the contextual factors are not department-based, but rather differ from person to person. As Miles and Huberman (1994) conclude: “But sometimes the conflicting findings are a blessing because the different data collection methods used gather different facets of data, and their combined effects build on each other to compose a more three-dimensional perspective of the phenomenon” (M. B. Miles & Huberman, 1994, p. 300). The next figure summarizes the propositions made.

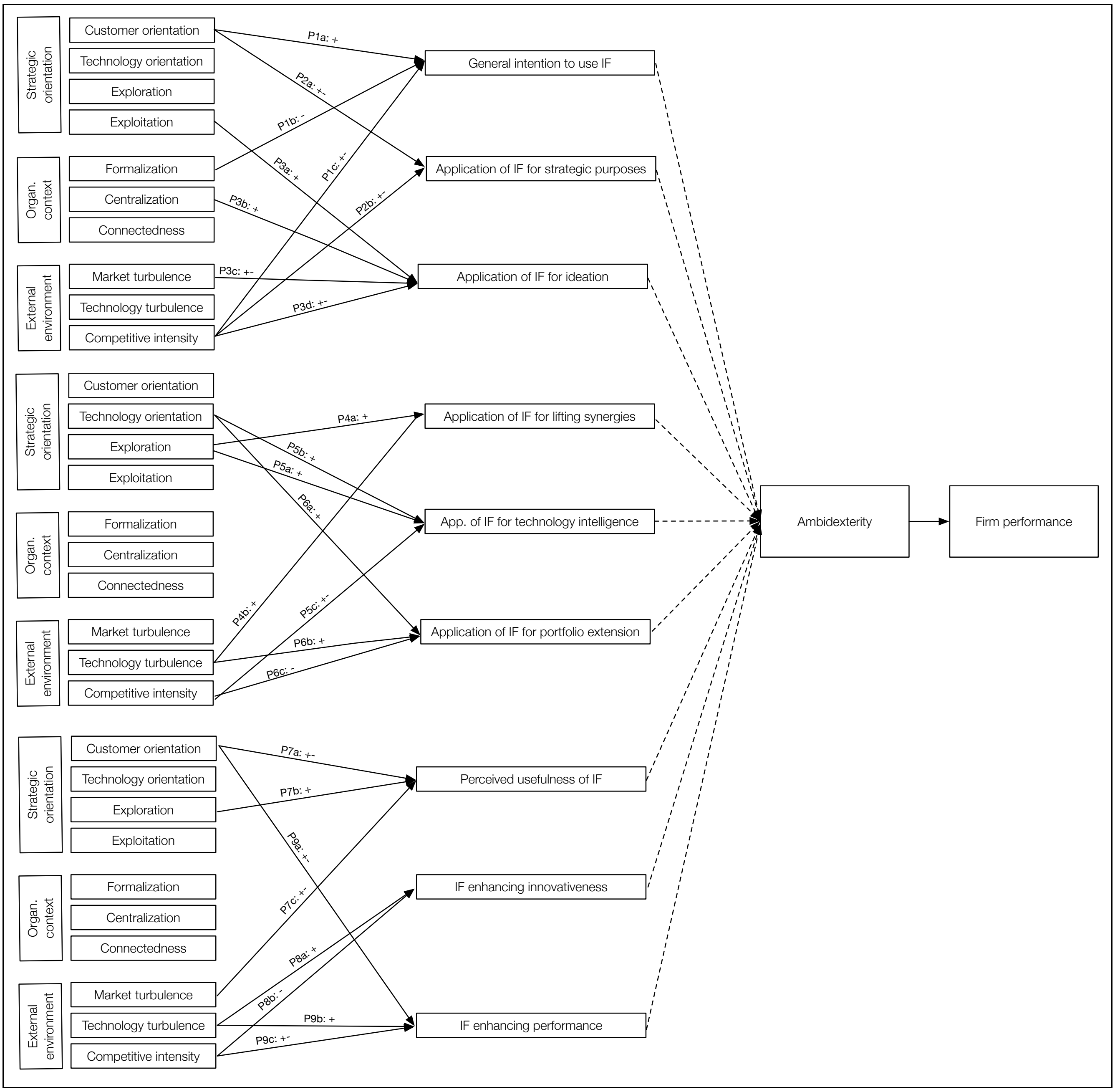


Figure 66: Overview of Propositions for Intended Application and Perceived Proficiency of IF

Notes:
Source: own representation

7 Conclusions

This chapter presents theoretical contributions, managerial implications and discusses limitations and future research, followed by an outlook.

STRUCTURE OF CHAPTER 7: CONCLUSIONS
7.1 Theoretical Contributions 7.2 Managerial Implications 7.3 Limitations and Future Research Directions 7.4 Outlook

Figure 67: Chapter Overview of Conclusions
Notes:
Source: own representation

7.1 Theoretical Contributions

The underlying dissertation had the objective to create a better understanding of the concept of innovation fields, an instrument to structure the front-end of innovation and to foster ambidexterity. Ambidexterity is a concept derived from organizational learning theory. Organizational learning is best described through the reflection of the organizations own experiences and those of others that thereby shape decisions (Argote et al., 1990, p. 1124). These decisions are then translated into changing routines such as processes, strategies, and habits, indicating that organizational learning occurred (Argote & Miron-Spektor, 2011, p. 1123; Levitt & March, 1988, p. 320). Especially regarding the connection between organizational learning and innovation, the aspect of search strategies for new product development[28] (NPD) is crucial for the renewal of the firm (Danneels, 2002, p. 1115). Renewal of the firm comprises expanding competencies, changing market fields, product offerings, structures and routines (Danneels, 2002, p. 1095; Teece, 2007, p. 1135). Two search strategies can be distinguished: exploration and exploitation (Greve, 2007, p. 945; March, 1991, p. 71). Exploration is the search for new products and technologies, thereby enhancing the existing competencies of the organization, while exploitation is the refinement and utilization of previously-acquired competencies (Greve, 2007, p. 945; March, 1991, p. 71). The balance between exploitation and exploration is called ambidexterity (Tushman & O'Reilly, 1996) and it is crucial for long-term survival (Levinthal & March, 1993), prosperity (March, 1991) and sustainable firm performance (Gibson & Birkinshaw, 2004, p. 212). Since both search strategies require the allocation of resources, they cause a trade-off making it less difficult to focus on one single search strategy than the balanced combination of both (Benner & Tushman, 2003, p. 245; Greve, 2007, p. 945; March, 1991, p. 72). Research regarding building ambidexterity believes that either the structural division of tasks (structural ambidexterity) or the creation of a context that allows the simultaneous pursuit of exploration and exploitation, such as practices or policies and their according contextual factors foster ambidexterity (Gibson & Birkinshaw, 2004, p. 210; Tushman & O'Reilly, 1996, p. 24). Although literature has described that ambidexterity positively influences long-term success (Gibson & Birkinshaw, 2004, p. 212; Katila & Ahuja, 2002, p.

[28] New product development encompasses all innovation activities leading from an initial idea to a commercialized offering on the market.

1191; C. Kim et al., 2012, p. 1193; Levinthal & March, 1993; March, 1991) and what influences fostering ambidexterity as a capability (Jansen et al., 2006, p. 1664; Raisch & Birkinshaw, 2008, p. 381; Raisch et al., 2009, p. 685; Tushman & O'Reilly, 1996, p. 11), research does not outline solutions on how organizations can reach and sustain ambidexterity (Cantarello et al., 2012, p. 45; Z. Wei, Yi, et al., 2014, p. 833).

Especially in the front-end of innovation, where the creation of value takes place (Markham, 2013; Reid & de Brentani, 2004, p. 172) and search for and initiation of innovation is the dominant activity, the question of structure and process formalization is prevalent (Nobelius & Trygg, 2002, p. 338). Formalization in the front-end of innovation is a double-edged sword. On the one hand, formalization reduces flexibility and increases bureaucracy, while at the same time it can cope with rising complexity and ensure common understanding, helping to cut time and cost (Adler & Borys, 1996, p. 63; Kleinschmidt et al., 2007, p. 431; Tatikonda & Rosenthal, 2000, p. 405).

Thus, innovation fields are introduced as structuring instrument in the front-end of innovation, determining the strategy, scope, depth, and locus of the innovation search by setting search boundaries and establishing guidelines. These guidelines are "related by one common theme, which can be a customer need, a core competence, a technology platform, or any combination of these" (Salomo et al., 2008, p. 561; Talke et al., 2010, p. 909). The innovation strategy is determined by the sum of innovation fields, ensuring that corporate goals are aligned with innovation activities (Khurana & Rosenthal, 1998, p. 59; Salomo et al., 2008, p. 561), fostering the balance between exploitative and explorative activities, by linking innovation activities towards their contribution to either exploration or exploitation and ensuring dynamic and quick re-alignment of resources, if needed.

Since research on innovation fields is scarce, this thesis set out to answer how and why perceived contextual factors influence the intended applications and perceived proficiency of innovation fields in a corporate context, to get a better understanding of how innovation fields are applied and which factors influence the usage.

Several theoretical contributions can be made, which can be divided into two separate streams: (1) contributions to organizational learning theory and (2) contributions to innovation research, especially regarding the front-end of innovation.

Contributions to Organizational Learning Theory

From the obtained results of the embedded single case design, several contributions can be made towards organizational learning theory and ambidexterity research.

Several papers argue that previous research does not offer an answer concerning how organizations can dynamically adapt their resource portfolios to reach ambidexterity (Cantarello et al., 2012, p. 45; Judge & Blocker, 2008, p. 922; Z. Wei, Yi, et al., 2014, p. 833). With innovation fields structuring the strategic phase of the front-end of innovation, organizations have an instrument at hand to facilitate the shift of resources and to prioritize innovation activities according to their contribution towards exploiting existing competencies and exploring new competencies. Accordingly, they foster ambidexterity by balancing explorative and exploitative innovation fields (Raisch & Birkinshaw, 2008, p. 401).

The underlying dissertation extends the understanding of how to adapt and align resources to build ambidexterity with innovation fields. They constitute an instrument to increase the awareness of balancing innovation activities in the most important part of the NPD process, the front-end of innovation (Markham, 2013; Reid & de Brentani, 2004, p. 172). In this phase, value is created, and with innovation fields, the balance between exploration and exploitation can be ensured while aligning activities with corporate goals. As the choice of innovation projects is balanced between risk and revenue, innovation activities in the front-end of innovation can be balanced according to their contribution to exploration and exploitation. Thus, innovation fields connect innovation activities in the front-end of innovation with the overall goal of building ambidexterity as an organization.

However, the implementation of innovation fields does not guarantee that ambidexterity can be reached. Studies suggest that balancing exploration and exploitation is moderated by specific capabilities of the organization, such as resource and coordination flexibility and capacity for change (Judge & Blocker, 2008, p. 922; Z. Wei, Yi, et al., 2014, p. 843; K. Z. Zhou & Wu, 2010, p. 558). These comprise the ability of a firm to build resources that can be used in multiple ways and the ability to create new resources and abilities by coordinating the mix of existing ones or adapting the existing ones (Judge & Blocker, 2008, p. 919; Z. Wei, Yi, et al., 2014, p. 834). Thus, the application of innovation fields within an organization might be insufficient to foster ambidexterity.

Regarding contextual factors influencing ambidexterity, interesting findings could be obtained. Generally, evidence was found that the derived main contextual factors influencing ambidexterity also influence the intended types of applications for innovation fields and their perceived proficiency, although the degree of influence, however, varies across strategic orientation, organizational context, and external environment.

For strategic orientation, primarily explorative orientation and customer orientation show an impact on innovation field application. These findings indicate that organizations that are better at exploiting their existing competencies might have a greater need to use innovation fields when the adaptation requires explorative orientation, supporting study results that vouch for a relative balance between exploration and exploitation in dependence on the capabilities of the organization (Z. Wei, Yi, et al., 2014, p. 844). Additionally, it could be shown that there exists a curvilinear relationship between customer orientation and innovation field application and perceived proficiency, offering new insights into the effect direction of customer orientation. In this study, an inverse U-shaped relationship was discovered, implicating that only moderate levels of customer orientation have a positive impact on intended innovation field application, while under high customer orientation, innovation activities are derived directly from the customer. In these cases, it might be argued that customers determine the balance between exploration and exploitation.

On the other hand, organizational context does not show major influence on intended innovation field application and perceived proficiency. Although research suggests that the setting of the context is of great importance to foster ambidexterity, the study results remain inconclusive regarding this contextual factor (Gibson & Birkinshaw, 2004, p. 213; Jansen et al., 2006, p. 1664; Raisch & Birkinshaw, 2008, p. 381). It seems that either organizational factors have no impact on the intended application of innovation fields or that other organizational factors have a bigger impact, however, have not been discovered and examined. Thus, the underlying thesis raises the question if the importance of organizational context to foster ambidexterity is as important as claimed by previous research.

The results also show a strong influence of the external environment factors on the intended innovation field application and perceived proficiency. While technology turbulence shows positive effects for intended innovation field applications and perceived proficiency, an inverse U-shaped effect for competitive intensity is found. Studies suggest the re-alignment and adaption of innovation activities is of great importance under high turbulence and competitive intensity (Auh & Menguc, 2005, p. 1654; Zahra, 1993, p. 324), making the shift of resources and topics more important. Other studies claim that competitive intensity and turbulence is a boundary condition for organizations to pursue and foster ambidexterity (Jansen et al., 2005, p. 352; Raisch & Birkinshaw, 2008, p. 394). Although the findings show a strong influence of competitive intensity on intended innovation field applications and perceived proficiency, the effect direction is either negative or inverse U-shaped. Thus, innovation fields as an instrument to foster ambidexterity, are used under low to moderate competitive intensity. In cases of high competitive intensity, innovation is de-prioritized, leading to innovation inertia. Imitation and cost reduction are the preferred reactions towards rising competition reduction (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723). Overall, the underlying dissertation substantiates previous findings towards organizational behavior under hostile environmental conditions, while delivering valuable insights into fostering ambidexterity in such conditions. For the balance of exploration and exploitation under turbulent surroundings, enhanced awareness and caution need to be taken to maintain the balance for innovation activities.

Furthermore, the study examined contextual factors on the individual level rather than the firm level obtaining insights into how ambidexterity can be fostered on the individual level, a fact that is often neglected in previous research (Gibson & Birkinshaw, 2004, p. 215; He & Wong, 2004). Additionally, by focusing on the perception of contextual factors, the subjective experience and judgement is obtained, which is of special importance, since it is assumed that people behave according to their subjective perceptions rather than factual reality (Ferris & Kacmar, 1992, p. 94; Lewin, 1936, p. 19).

Finally, the findings contribute to ambidexterity research by showing that reaching the balance between exploration and exploitation is not dependent on a single factor but influenced by several contextual factors, making the achievement of ambidexterity a multi-faceted phenomenon requiring a holistic perspective.

Contributions to Research on the Front-End of Innovation

Moreover, contributions can be made to innovation research, especially regarding the front-end of innovation. Being able to manage the front-end of innovation can bring distinct competitive advantages to companies (J. Kim & Wilemon, 2002b, p. 27). The understanding of innovation fields as a structuring instrument for the strategic phase of the front-end of innovation could be extended by defining the concept of innovation fields comprehensively and highlighting different types of applications for innovation fields. The different applications of innovation fields that were outlined in existing literature could be shown empirically, extending research about the function and purpose of innovation fields in organizations. Furthermore, contextual factors influencing the general application of innovation fields and the outlined types of applications could be shown. Thus, this study is the first to explore the intended application of innovation fields in a corporate context and enhance the existing body of knowledge regarding contextual factors that influence the application such as strategic orientation, organizational context, and external environment. Evidence was found for the influence of contextual factors on the intended application of innovation fields. This study is the first to explore the context-sensitivity of innovation fields, creating a framework to show contextual factors influencing the innovation field applications. Prior studies did not distinguish between different types of application, and no research had been conducted on what factors influences the usage. Thus, this thesis adds to the existing body of knowledge regarding innovation fields. Furthermore, a contribution could be made to the ongoing debate around structure and formalization by introducing innovation fields as instrument that makes sure that the NPD process stays responsive and does not become stale (Adams-Bigelow, 2004, p. 549; Raisch & Birkinshaw, 2008, p. 401), by guiding the front-end of innovation, but allowing for dynamic re-alignment.

7.2 Limitations and Future Research Directions

This study holds several limitations that need to be addressed. First, only one company was tested in the very specific context of a corporate R&D division. Innovation projects in R&D settings often precede commercialization for 15-20 years. Thus, future research should test whether the results differ in, e.g. fast moving consumer goods. Additionally, although the corporate R&D division offers a variety of different research areas and topics, future research should test innovation field application and proficiency in other industries. Furthermore, the selected case was an R&D division based in Germany. Future research should take different cultural contexts into account.

Additionally, the low explained variance implies that the framework for the contextual factors influencing intended innovation field applications and perceived proficiency should be extended. For instance, it was obtained that organizational context (apart from formalization) only plays a minor role in explaining intended innovation field applications and proficiency, which needs further investigation. It seems that either organizational factors actually do not influence the application of innovation fields or that other factors influence the application that have not been tested in the study. The control variable managerial responsibility showed great negative influence on intended innovation field applications, indicating that this fact should be investigated further. As in the study from Talke et al. (2010), the assessment and impact of different leadership styles should be measured towards application and proficiency of innovation fields (Talke et al., 2010). Furthermore, this study focuses on contextual factors. It should be examined whether structural factors affect the application and proficiency of innovation fields.

Regarding the proficiency, only soft factors were considered, such as the perceived usefulness, overall perceived performance, and innovativeness. Due to the short time frame since the implementation of innovation fields in the organization, no other measures could be integrated into the study. Thus, future studies should deepen insights regarding the performance of innovation fields and test the impact of innovation fields on ambidexterity in longitudinal studies.

Furthermore, the underlying study did not consider whether the actual definition of innovation fields, such as the title, description or scope of innovation field influence the intended types of applications or proficiency. Moreover, future studies should also examine the influence of the online information system used for storage of innovation fields.

While studies examining behavior and perceptions are able to describe the relation between variables, the effects and relationships can never be predicted with certainty (R. W. Griffin & Moorhead, 2010, p. 14). Although the qualitative and quantitative study showed different effect directions and divergent results, the importance of mixed-methods research and the triangulation of qualitative and quantitative data should be endorsed.

7.3 Managerial Implications

This study offers several important managerial implications regarding innovation fields. First, innovation fields pose an adaptive and flexible instrument in the front-end of innovation to support the conversion of corporate strategy into guidelines and innovation activities. Innovation fields defy strict formalization, while they do carry sufficient guidance for employees to hold creative constraints and friction.

Second, innovation fields support achieving ambidexterity by employing them for either explorative or exploitative endeavors. With established innovation fields, both activities can be balanced out steadily.

Third, this study shows that several innovation field applications can be distinguished. This study gives insights into the different types of applications to facilitate the precise and effective implementation in organizations, making sure employees and managers alike are aware of the multidimensional nature of innovation fields.

Fourth, this study unveiled that specific contextual factors influence the intended application of innovation fields. This entails that in the case of implementation of innovation fields within an organization, it should be checked whether the strategical, organizational, and environmental context matches the chosen type of application. Besides the contextual factors, managers should ensure that the application of innovation fields in the organization corresponds to the working habits of the employees to ensure proper use. Thus, organizations should analyze upfront which contextual setting the organization encounters, to implement innovation fields effectively. In settings where innovation fields already have been implemented, this study offers insights into how they can be used more effectively depending on what application is chosen. Interestingly and shown by various studies, in the case of high competitive intensity, focus on innovation decreases (Baker & Sinkula, 2007, p. 326; Bonanno & Haworth, 1998, p. 502; Boone, 2001, p. 723). Furthermore, this study reveals decreasing focus on innovation in times of high competitive intensity. Organizations should focus on innovation despite external turbulence to sustain competitive advantage, innovation fields being a flexible instrument for this endeavor. A similar managerial implication can be drawn for the factor customer orientation. The application and perceived proficiency of innovation fields decrease when customer orientation is perceived as high. In these cases, innovation activities are aligned with the needs and requirements of customers and organizations might be rather customer-led than customer-oriented (Slater & Narver, 1998). In this case, innovation activities are not aligned with ambidexterity goals, but solely with customer demands, leading to unbalanced innovation activities such as the prioritization of exploitative innovation. Thus, when encountering high customer orientation, the balance of innovation activities should still be focused, using innovation fields to establish a counter-balance.

Managerial responsibility showed a negative effect on intended innovation field application and perceived proficiency. While this finding implies that managers simply do not need innovation fields due to the distinct knowledge about corporate goals and innovation strategy, this finding could also implicate that they feel offended in their role as executives. When implementing innovation fields, the alignment of managers with the overall objective of innovation fields as an instrument to structure the front-end of innovation and to foster ambidexterity should be ensured. A similar implication can be drawn for the satisfaction with the overall processes. If employees do not approve of the existing processes, the probability is high that new instruments will not be accepted either. Finally, the diverging results for innovation field application for software-intensive projects imply that the working habits should be considered when implementing innovation fields. Regardless if the divergence stems from the disapproval of the overall processes or from the way of working, the working mode and the application of innovation fields need to be aligned in order from them to be used properly.

Thus, the underlying dissertation provides managers with an instrument for the front-end of innovation that fosters ambidexterity and structures the front-end of innovation, while ensuring sufficient freedom for employees in the search for ideas and innovation. With innovation fields, managers can quickly re-align resources and enhance the awareness for the organization to follow either more explorative or exploitative innovation activities when a balance is not given.

7.4 Outlook

Innovation prevails as a dominant topic for organizations and a driver for sustainable success and competitive advantage (Legnick-Hall, 1992, p. 406; Ringel et al., 2015, p. 3; Rosenkopf & Nerkar, 2001, p. 287; Tidd, 2001, p. 170f.; Weerawardena, 2003, p. 26). However, the management of innovation remains affected by uncertainty and risk-taking, which is often frustrating for organizations (Pisano, 2015, p. 44). As Drucker already stated in 1985: "Most innovations, however, especially the successful ones, result from a conscious, purposeful search for innovation opportunities, which are found only in few situations" (Drucker, 1985, p. 68). Purposeful search implies the strategic alignment of corporate goals and innovation activities, which is one of the main challenges that R&D intensive companies are facing today (Staack et al., 2017, p. 7). Thus, companies have to set up an innovation strategy that aligns their corporate goals with innovation activities. Furthermore, successful companies balance their innovation activities between exploration and exploitation. Google continuously refines their advertisement business while exploring autonomous driving, and OEMs still invest heavily in the traditional automobile, while investigating disruptive business models like the sharing economy or alternative power trains (Pisano, 2015, p. 8). However, the management of innovation remains like a journey in an unexplored river with many turns and boulders as well as an unknown path. In this metaphor, innovation fields can serve as the lifebelt that guides companies through the river and brings them safely to the shore (van de Ven, 2017, p. 41).

8 Bibliography

Abernathy, W. J., & Clark, K. B. (1985). Innovation: Mapping the Winds of Creative Destruction. *Research Policy*, *14*(1), 3–22.

Abernethy, M. A., & Brownell, P. (1997). Management Control Systems in Research and Development Organizations: The Role of Accounting, Behavior and Personnel Controls. *Accounting, Organizations and Society*, *22*(3–4), 233–248.

Adams-Bigelow, M. (2004). First Results from the 2003 Comparative Performance Assessment Study (CPAS). In K. B. Kahn (Ed.), *The PDMA Handbook of New Product Development* (2nd ed., pp. 546–566). London: John Wiley & Sons.

Adler, P. S., & Borys, B. (1996). Two Types of Bureaucracy: Enabling and Coercive. *Administrative Science Quarterly*, *41*(1), 61–89.

Aiken, M., & Hage, J. (1968). Organizational Interdependence and Intra-Organizational Structure. *American Sociological Review*, *33*(6), 912–930.

Alegre, J., & Chiva, R. (2008). Assessing the Impact of Organizational Learning Capability on Product Innovation Performance: An Empirical Test. *Technovation*, *28*(6), 315–326.

Altshuller, G. (1999). *Innovation Algorithm: TRIZ, Systematic Innovation and Technical Creativity*. Worcester, MA: Technical Innovation Center.

Amabile, T. M. (1998). How to Kill Creativity. *Harvard Business Review*, *September*, 77–87.

Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the Work Environment for Creativity. *Academy of Management Journal*, *39*(5), 1154–1184.

Amabile, T. M., Mueller, J., Simpson, W., Hadley, C. N., Kramer, S. J., & Fleming, L. (2002). *Time Pressure and Creativity in Organizations: A Longitudinal Field Study* (HBS Working Paper No. 02–073). Boston, MA.

Ansoff, I. (1976). Managing Surprise and Discontinuity - Strategic Response to Weak Signals. *Schmalenbachs Zeitschrift Für Betriebswirtschaftliche Forschung*, *28*(3), 129–152.

Appelt, H. G. (1981). Suchfelder - Orientierungshilfen bei der Suche nach neuen Produkten. *Fortschrittliche Betriebsführung Und Industrial Engineering*, *30*(6), 418–425.

Argote, L., Beckmann, S. L., & Epple, D. (1990). The Persistence and Transfer of Learning in Industrial Settings. *Management Science*, *36*(2), 140–154.

Argote, L., & Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science*, *22*(5), 1123–1137.

Armstrong, J. S., & Overton, T. S. (1977). Estimating Nonresponse Bias in Mail Surveys. *Journal of Marketing*, *14*(3), 396–402.

Ashton, W., & Stacey, G. (1995). Technical Intelligence in Business: Understanding Technology Threats and Opportunities. *International Journal of Technology Management*, *10*(1), 79–104.

Atuahene-Gima, K. (1995). An Exploratory Analysis of the Impact of Market Orientation on New Product Performance. *Journal of Product Innovation Management*, *12*(4), 275–293.

Atuahene-Gima, K. (2003). The Effects of Centrifugal and Centripetal Forces on Product Development Speed and Quality : How Does Problem Solving Matter? *Academy of Management Journal*, *46*(3), 359–373.

Atuahene-Gima, K., Li, H., & De Luca, L. M. (2006). The Contingent Value of Marketing Strategy Innovativeness for Product Development Performance in Chinese New Technology Ventures. *Industrial Marketing Management*, *35*(3), 359–372.

Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A Survey. *Computer Networks*, *54*(15), 2878–2805.

Auh, S., & Menguc, B. (2005). Balancing Exploration and Exploitation: The Moderating Role of Competitive Intensity. *Journal of Business Research*, *58*, 1652–1661.

Auh, S., & Menguc, B. (2007). Performance Implications of the Direct and Moderating Effects of Centralization and Formalization on Customer Orientation. *Industrial Marketing Management*, *36*(8), 1022–1034.

Ayers, D., Dahlstrom, R., & Skinner, S. J. (1997). An Exploratory Investigation of Antecedents to Organizational New Product Success. *Journal of Marketing Research*, *34*(1), 107–116.

Backhaus, K., Erichson, B., Plinke, W., & Weiber, R. (2011). *Multivariate Analysemethoden*. Heidelberg: Springer Verlag.

Bajpai, N. (2010). *Business Statistics*. Upper Saddle River (NJ): Pearson Education.

Baker, W. E., & Sinkula, J. M. (2007). Does Market Orientation Facilitate Balanced Innovation Programs? An Organizational Learning Perspective. *Journal of Product Innovation Management*, *24*(4), 316–334.

Banville, D., Desroisiers, P., & Genet-Volet, Y. (2000). Translation Questionnaires and Inventories using a cross-cultural translation technique. *Journal of Teaching in Physical Education*, *19*, 374–387.

Baraldi, A. N., & Enders, C. K. (2013). Missing Data Methods. In T. D. Little (Ed.), *The Oxford Handbook of Quantitative Methods - Volume 2: Statistical Analysis* (pp. 635–664). Oxford: Oxford University Press.

Benner, M. J., & Tushman, M. L. (2002). Process Management and Technological Innovation: A Longitudinal Study of the Photography and Paint Industries. *Administrative Science Quarterly*, (4), 676–706.

Benner, M. J., & Tushman, M. L. (2003). Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited. *Academy of Management Review*, *28*(2), 238–256.

Birkinshaw, J., & Gibson, C. (2004). Building Ambidexterity into an Organisation. *MIT Sloan Management Review*, 47–55.

Birkinshaw, J., Hamel, G., Mol, M. J., & Mol, M. I. (2008). Management Innovation. *The Academy of Management Review*, *33*(4), 825–845.

Boeddrich, H.-J. (2004). Ideas in the Workplace: A New Approach Towards Organizing the Fuzzy Front End of the Innovation Process. *Creativity and Innovation Management*, *13*(4), 274–285.

Bogner, A., & Menz, W. (2009). The Theorgy-Generating Expert Interview: Epistemological Interest, Forms of Knowledge, Interaction. In A. Bogner, B. Littig, & W. Menz (Eds.), *Interviewing experts* (pp. 43–80). Hampshire: Palgrave Macmillan.

Bolton, R. N. (1993). Pretesting Questionnaires: Content Analyses of Respondents' Concurrent Verbal Protocols. *Marketing Science*, *12*(3), 280–303.

Bonanno, G., & Haworth, B. (1998). Intensity of Competition and the Choice between Product and Process Innovation. *International Journal of Industrial Organization*, *16*, 495–510.

Bonner, J., Ruekert, R., & Walker, O. (2002). Upper Management Control of New Product Development Projects and Project Performance. *Journal of Product Innovation Management*, *19*(3), 233–245.

Boone, J. (2001). Intensity of Competition and the Incentive to Innovate. *International Journal of Industrial Organization*, *19*(5), 705–726.

Booz Allen, & Hamilton. (1982). *New Product Management for the 1980s*. New York: Booz, Allen and Hamilton.

Bower, J. L., & Christensen, C. M. (1995). Disruptive Technologies: Catching the Wave. *Harvard Business Review*, *73*(1), 45–53.

Bozdogan, H. (1987). Model Selection and Akaike's Information Criterion (AIC): The General Theory and its Analytical Extensions. *Psychometrika*, *52*(3), 345–370.

Brannen, J. (1992). Combining Qualitative and Quantitative Approaches: An Overview. In J. Brannen (Ed.), *Mixing Methods: Qualitative and Quantitative Research* (1st ed., pp. 3–37). Aldershot: Avebury.

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2014). How Virtualization, Decentrazliation and Network Building Change the Manufacturing Landscape: An Industry 4.0 Perspective. *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering*, *8*(1), 37–44.

Brooks, F. (1987). No Silver Bullet - Essence and Accidents of Software Engineering. *IEEE Computer*, *20*(4), 10–19.

Brown, T. (2008). Design Thinking. *Harvard Business Review*, *6*, 85–92.

Brown, T. (2009). *Change by Design*. New York: HarperCollins.

Bruner, G. C., & Hensel, P. J. (1993). Multi-Item Scales Usage in Marketing Journals: 1980 to 1989. *Journal of the*

Academy of Marketing Science, (Fall), 339–344.

Bryman, A. (2004). *Social Resarch Methods* (2nd ed.). Oxford: Oxford University Press.

Bryman, A. (2006). Integrating Quantitative and Qualitative Research: How is it Done? *Qualitative Research*, *6*(1), 97–113.

Buggie, F. D. (2002). Set the “Fuzzy Front End” in Concrete. *Research Technology Management*, *45*(4), 11–14.

Cagan, J., & Vogel, C. M. (2002). *Creating Breakthrough Products*. Upper Saddle River (NJ): Prentice Hall International.

Calantone, R. J., Cavusgil, S. T., & Zhao, Y. (2002). Learning Orientation, Firm Innovation Capability, and Firm Performance. *Industrial Marketing Management*, *31*(6), 515–524.

Calantone, R. J., Chan, K., & Cui, A. S. (2006). Decomposing Product Innovativeness and its Effects on New Product Success. *Journal of Product Innovation Management*, *23*(5), 408–421.

Calantone, R. J., Garcia, R., & Dröge, C. (2003). The Effects of Environmental Turbulence on New Product Development Strategy Planning. *Journal of Product Innovation Management*, *20*, 90–103.

Candi, M., Van Den Ende, J., & Gemser, G. (2013). Organizing Innovation Projects Under Technological Turbulence. *Technovation*, *33*(4–5), 133–141.

Cantarello, S., Martini, A., & Nosella, A. (2012). A Multi-Level Model for Organizational Ambidexterity in the Search Phase of the Innovation Process. *Creativity and Innovation Management*, *21*(1), 28–48.

Cardinal, L. B. (2001). Technological Innovation in the Pharmaceutical Industry: The Use of Organizational Control in Managing Research and Development. *Organization Science*, *12*(1), 19–36.

Chang, Y. Y., & Hughes, M. (2012). Drivers of Innovation Ambidexterity in Small- to Medium-Sized Firms. *European Management Journal*, *30*(1), 1–17.

Chao, R. O., & Kavadias, S. (2008). A Theoretical Framework for Managing the New Product Development Portfolio: When and How to Use Strategic Buckets. *Management Science*, *54*(5), 907–921.

Cheng, Y.-T., & van de Ven, A. H. (1996). Learning the Innovation Journey: Order out of Chaos? *Organization Science*, *7*(6), 593–614.

Chenhall, R. H. (2003). Management Control Systems Design within its Organizational Context: Findings from Contingency-Based Research and Directions for the Future. *Accounting, Organizations and Society*, *28*, 127–168.

Cho, H.-J., & Pucik, V. (2005). Relationship between Innovativeness, Quality, Growth, Profitability and Market Value. *Strategic Management Journal*, *26*(6), 555–575.

Churchill, G. A. (1979). A Paradigm for Developing Better Measures of Marketing Constructs. *Journal of Marketing Research*, *XVI*, 64–73.

Churchill, G. A., & Peter, P. (1984). Research Design Effects on the Reliability of Rating Scales: A Meta-Analysis. *Journal of Marketing Research*, *XXI*(November), 360–375.

Clark, K. B., & Fujimoto, T. (1991). *Product Development Performance - Strategy, Organization, and Management in the World Auto Industry*. Boston: Harvard Business School Press.

Clark, K. B., & Wheelwright, S. C. (1997). Organizing and Leading “Heavyweight” Development Teams. In M. L. Tushman & P. Anderson (Eds.), *Managing Strategic Innovation and Change* (pp. 419–432). Oxford: Oxford University Press.

Clausen, T., Geschka, H., & Krug, J. (2012). Innovationsstrategien. In S. Ili (Ed.), *Innovation Excellence - Wie Unternehmen ihre Innovationsfähigkeit Systematisch Steigern* (1st ed., pp. 95–128). Düsseldorf: Symposion Publishing.

Colarelli O’Connor, G., & Ayers, A. (2005). Building a Radical Innovation Competency. *Research Technology Management*, *48*(1), 23–31.

Colarelli O’Connor, G., Leifer, R., Paulson, A. S., & Peters, L. S. (2008). *Grabbing Lightning: Building a Capability for Breakthrough Innovation*. San Francisco: Jossey-Bass.

Colombo, M. G., D’Adda, D., & Pirelli, L. (2016). The Participation of New Technology-Based Firms in EU-Funded R&D Partnerships: The Role of Venture Capital. *Research Policy*, *45*, 361–375.

Cooper, R. G. (1983). A Process Model for Industrial New Product Development. *IEEE Transactions on Engineering Management*, *30*(1), 2–11.

Cooper, R. G. (1984). New Product Strategies: What Distinguishes the Top Performers? *Journal of Product Innovation Management*, *2*(1), 151–164.

Cooper, R. G. (1988). Predevelopment Activities Determine New Product Success. *Industrial Marketing Management*, *17*(3), 237–247.

Cooper, R. G. (2005). Attention: Results are Down. *NPD Practices*, *29*(2), 22–26.

Cooper, R. G. (2008). Perspective: The Stage-Gate Idea-to-Launch Process - Update, What's New and NexGenSystems. *Journal of Product Innovation Management*, *25*(3), 213–232.

Cooper, R. G., Edgett, S., & Kleinschmidt, E. J. (2001). *Portfolio Management for New Products* (2nd ed.). Cambridge: Perseus Book Group.

Cooper, R. G., Edgett, S., & Kleinschmidt, E. J. (2002). Optimizing the Stage-Gate Process - What Best-Practice Companies Do. *Research Technology Management*, *45*(6), 43–49.

Cooper, R. G., Edgett, S., & Kleinschmidt, E. J. (2004). Benchmarking Best NPD Practices-II. *Research Technology Management*, *47*(3), 1–11.

Cooper, R. G., & Kleinschmidt, E. J. (1986). An Investigation into the New Product Process: Steps, Deficiencies and Impact. *Journal of Product Innovation Management*, *3*(2), 71–85.

Cooper, R. G., & Kleinschmidt, E. J. (1987). New Products: What Separates Winners from Losers? *Journal of Product Innovation Management*, *4*(3), 169–184.

Cooper, R. G., & Kleinschmidt, E. J. (1991). New Product Processes at Leading Industrial Firms. *Industrial Marketing Management*, *20*(2), 137–147.

Cooper, R. G., & Kleinschmidt, E. J. (1994). Screening New Products for Potential Winners. *IEEE Engineering Management Review*, *26*(6), 74–81.

Cooper, R. G., & Kleinschmidt, E. J. (2001). Stage-Gate Process for New Product Success. *Innovation Management*, 1–8.

Cortimiglia, M. N., Ghezzi, A., & Germán Frank, A. (2016). Business Model Innovation and Strategy Making Nexus: Evidence from a Cross-Industry Mixed-Methods Study. *R&D Management*, *46*(3), 414–432.

Coyne, K. P., Clifford, P. G., & Dye, R. (2007). Breakthrough Thinking from Inside the Box. *Harvard Business Review*, *85*(12), 70–78.

Craighead, C. W., Ketchen, D. J., Dunn, K. S., & Hult, G. T. M. (2011). Addressing Common Method Variance: Guidelines for Survey Research on Information Technology, Operations, and Supply Chain Management. *IEEE Transactions on Engineering Management*, *58*(3), 578–588.

Crawford, M. (1980). Defining the Charter for Product Innovation. *Sloan Management Review*, *22*(3), 3–12.

Creswell, J. W. (2013). *Qualitative Inquiry and Research Design* (3rd ed.). Thousand Oaks: Sage Publications.

Curran, J., & Blackburn, R. A. (2001). *Researching the Small Enterprise*. Thousand Oaks: Sage Publications.

Cyert, R., & March, J. G. (1963). *Behavioral Theory of the Firm*. Cambridge (MA): Blackwell Publishing.

Damanpour, F. (1991). Organizational Innovation: A Meta-Analysis of effects of Determinants and Moderators. *Academy of Management Journal*, *34*(3), 355–590.

Danneels, E. (2002). The Dynamics of Product Innovation and Firm Competences. *Strategic Management Journal*, *23*(12), 1095–1121.

Danneels, E., & Kleinschmidt, E. J. (2001). Product Innovativeness from the Firm's Perspective: Its Dimensions and Their Relation with the Project Selection and Performance. *Journal of Product Innovation Management*, *18*(6), 357–373.

Danneels, E., & Sethi, R. (2011). New Product Exploration Under Environmental Turbulence. *Organization Science*, *22*(4), 1026–1039.

De Massis, A., Frattini, F., & Pizzurno, E. (2013). Product Innovation in Family vs . Non-Family Firms: An Exploratory Analysis. *Journal of Small Business Management*, *53*(1), 1–36.

de Ven, A. H., & Cheng, Y.-T. (1996). Learning the Innovation Journey: Order out of chaos? *Organization Science*, *7*(6), 593–614.

Denzin, N. K. (1989). *The Research Act: A Theoretical Introduction to Sociological Methods* (3rd ed.). Englewood Cliffs (NJ): Prentice Hall International.

Denzin, N. K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research*, *6*(2), 80–88.

Denzin, N. K., & Lincoln, Y. S. (2011). *The SAGE Handbook of Qualitative Research* (4th ed.). Thousand Oaks: Sage Publications.

Deshpandé, R., Farley, J. U., & Webster, F. E. J. (1993). Corporate Culture, Customer Orientation, and Innovativeness in Japanese Firms: A Quadrad Analysis. *Journal of Marketing*, *57*(1), 23–37.

Deshpande, R., & Zaltman, G. (1982). Factors Affecting The Use of Market Research Information: A Path Analysis. *Journal of Marketing Research*, *19*(1), 14–31.

Desouza, K. C. (2003). Barriers to Effective Use of Knowledge Management Systems in Software Engineering. *Communications of the ACM*, *46*(1), 99–101.

Dosi, G. (1988). Sources, Procedures, and Microeconomic Effects of Innovation. *Journal of Economic Literature*, *26*(3), 1120–1171.

Dougherty, D., & Hardy, C. (1996). Sustained Product Innovation in Large, Mature Organizations: Overcoming Innovation to Organization Problems. *Academy of Management Journal*, *39*(5), 1120–1153.

Drazin, R., & Bird Schoonhoven, C. (1996). Community, Population and Organization Effects on Innovation: A Multi-Level Perspective. *Academy of Management Journal*, *39*(5), 1065–1083.

Drucker, P. F. (1955). *The Practice of Management (reprint from 2007)*. Amsterdam: Elsevier.

Drucker, P. F. (1985). The Discipline of Innovation. *Harvard Business Review*, *63*(3), 67–72.

Durmusoglu, S. S., & Barczak, G. (2011). The Use of Information Technology Tools in New Product Development Phases: Analysis of Effects on New Product Innovativeness, Quality, and Market Performance. *Industrial Marketing Management*, *40*, 321–330.

Dwyer, L., & Mellor, R. (1991). Organizational Environment, New Product Process Activities and Project Outcomes. *Journal of Product Innovation Management*, *8*(1), 39–48.

Dyba, T., & Dingsoyr, T. (2008). Empirical Studies of Agile Software Development: A Systematic Review. *Information and Software Technology*, *50*(9–10), 833–859.

Dyer, J., & Gregersen, H. (2015). How We Rank The World's Most Innovative Companies 2015. Retrieved August 8, 2016, from https://www.forbes.com/sites/innovatorsdna/2015/08/19/how-we-rank-the-worlds-most-innovative-companies-2015/#987728a5f8c5

Edwards, T. (2007). Organizational Politics and The Process of Knowing - Understanding Crisis Events during Project-Based Innovation Projects. *European Journal of Innovation Management*, *10*(3), 391–406.

Eichhorn, B. R. (2014). Common Method Variance Techniques. In *Midwest SAS Users Group* (pp. 1–11). Chicago: MidWest SAS Users Group Conference.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Academy of Management Review*, *14*(4), 532–550.

Eisenhardt, K., & Martin, J. A. (2000). Dynamic Capabilities: What are They? *Strategic Management Journal*, *21*(10/11), 1105–1121.

Escobar-Rodríguez, T., Monge-Lozano, P., & Romero-Alonso, M. M. (2012). Acceptance of E-Prescriptions and Automated Medication-Management Systems in Hospitals: An Extension of the Technology Acceptance Model. *Journal of Information Systems*, *26*(1), 77–96.

Ethiraj, S., Gambardella, A., & Helfat, C. (2017). Author Guidelines. Retrieved January 5, 2017, from http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291097-0266/homepage/ForAuthors.html

Ettlie, J. E., & Elsenbach, J. M. (2007). Modified Stage-Gate Regimes in New Product Development. *Journal of Product Innovation Management*, *24*(1), 20–33.

Fast Company. (2016). Most Innovative Companies. Retrieved August 8, 2016, from https://www.fastcompany.com/most-innovative-companies

Ferris, G., & Kacmar, M. (1992). Perceptions of Organizational Politics. *Journal of Management*, *18*(1), 93–116.

Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative Cognition: Theory, Research, and Applications*. Bradford: The MIT Press.

Firth, R. W., & Narayanan, V. K. (1996). New Product Strategies of Large, Dominant Product Manufacturing Firms: An Exploratory Analysis. *Journal of Product Innovation Management*, *13*(4), 334–347.

Forbes. (2016). The World's Most Innovative Companies. Retrieved August 8, 2016, from https://www.forbes.com/innovative-companies/#522c67b01d65

Forrester, R. H. (2000). Capturing Learning and Applying Knowledge: An Investigation of the Use of Innovation Teams in Japanese and American Automotive Firms. *Journal of Business Research*, *47*(1), 35–45.

Frishammar, J., & Ake Hörte, S. (2005). Managing External Information in Manufacturing Firms: The Impact on Innovation Performance. *Journal of Product Innovation Management*, *22*(3), 251–266.

Frishammar, J., Lichtenthaler, U., & Kurkkio, M. (2012). The Front End in Non-Assembled Product Development: A Multiple Case Study of Mineral- and Metal Firms. *Journal of Engineering and Technology Management*, *29*(4), 468–488.

Galbraith, C., & Schendel, D. (1983). An Empirical Analysis of Strategy Types. *Strategic Management Journal*, *4*(2), 153–173.

Galunic, C. M., & Eisenhardt, K. M. (1996). The Evolution of Intracorporate Domains: Divisional Charter Losses in High-Technology, Multidivisional Corporations. *Organization Science*, *7*(3), 255–282.

Garcia, R., & Calantone, R. J. (2002). A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review. *Journal of Product Innovation Management*, *19*(2), 110–132.

Gartner, W. B. (1990). What Are We Talking About When We Talk about Entrepreneurship? *Journal of Business Venturing*, *5*, 15–28.

Gassmann, O., Frankenberger, K., & Csik, M. (2014). Revolutionizing the Business Model. In O. Gassmann & K. Frankenberg (Eds.), *Management of the Fuzzy Front End of Innovation*. Heidelberg: Springer Verlag.

Gatignon, H., Tushman, M. L., Smith, W., & Anderson, P. (2002). A Structural Approach to Assessing Innovation: Construct Development of Innovation Locus, Type, and Characteristics. *Management Science*, *48*(9), 1103–1122.

Gatignon, H., & Xuereb, J. M. (1997). Strategic Orientation of the Firm and New Product Performance. *Journal of Marketing Research*, *34*(1), 77–90.

Gibson, C. B., & Birkinshaw, J. (2004). The Antecedents, Consequences, and Mediating Role of Organizational Ambidexterity. *Academy of Management Journal*, *47*(2), 209–226.

Gillier, T., Piat, G., & Truchot, P. (2010). Managing Innovation Fields in a Cross-Industry Exploratory Partnership with C–K Design Theory. *Journal of Product Innovation Management*, *27*(6), 883–896.

Gläser, J., & Laudel, G. (2009). On interviewing "Good" and "Bad" Experts. In A. Bogner, B. Littig, & W. Menz (Eds.), *Interviewing Experts* (pp. 117–137). Hampshire: Palgrave Macmillan.

Glassey, O. (2009). Exploring the Weak Signals of Start-Ups as a Folksonomic System. *Technology Analysis & Strategic Management*, *21*(3), 321–332.

Goldenberg, J., Mazursky, D., & Solomon, S. (1999). Toward Identifying the Inventive Templates of New Products: A Channeled Ideation Approach. *Journal of Marketing Research*, *36*(2), 200–211.

Gordon, S., Tarafdar, M., Cook Robert Maksimoski, R., & Rogowitz, B. (2008). Improving the Front End of Innovation with Information Technology. *Research Technology Management*, *51*(3), 50–58.

Göthlich, S. E. (2009). Zum Umgang mit fehlenden Daten in großzahligen empirischen Erhebungen. In S. Albers, D. Klapper, U. Konradt, A. Walter, & J. Wolf (Eds.), *Methodik der Empirischen Forschung* (pp. 119–135). Wiesbaden: Gabler Verlag.

Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, *78*(6), 1360–1380.

Green, S., Gavin, M., & Aiman-Smith, L. (1995). Assessing a Multidimensional Measure of Radical Technological Innovation. *IEEE Transactions on Engineering Management*, *42*(3), 203–214.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a Conceptual Framework for Mixed-Method

Evaluation Designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255–274.

Greve, H. R. (2007). Exploration and Exploitation Product Innovation. *Industrial and Corporate Change*, *16*(5), 945–975.

Griffin, A., & Hauser, J. (1993). The Voice of the Customer. *Marketing Science*, *12*(1), 1–27.

Griffin, R. W., & Moorhead, G. (2010). *Organizational Behavior* (9th ed.). Mason (OH): South-Western.

Griffiths-Hemans, J. (2006). Setting the Stage for Creative New Products: Investigating the Idea Fruition Process. *Journal of the Academy of Marketing Science*, *34*(1), 27–39.

Gruber, M., MacMillan, I. C., & Thompson, J. D. (2013). Escaping the Prior Knowledge Corridor: What Shapes the Number and Variety of Market Opportunities Identified Before Market Entry of Technology Start-ups? *Organization Science*, *24*(1), 280–300.

Halman, J. I. M., Hofer, A. P., & van Vuuren, W. (2003). Platform-Driven Development of Product Families: Linking Theory with Practice. *Journal of Product Innovation Management*, *20*(2), 149–162.

Hambrick, D. C., & Fredrickson, J. W. (2001). Are You Sure You Have a Strategy? *Academy of Management Executive*, *15*(4), 51–62.

Hammersley, M. (2008). Troubles with Triangulation. In M. M. Bergman (Ed.), *Advances in Mixed Methods Research* (pp. 22–36). London: Sage Publications.

Harman, H. H. (1960). *Modern Factor Analysis*. Chicago: University of Chicago Press.

Harrison, D., & Kjellberg, H. (2010). Segmenting a Market in the Making: Industrial Market Segmentation as Construction. *Industrial Marketing Management*, *39*(5), 784–792.

Hartline, M. D., Maxham, J. G., & McKee, D. O. (2000). Corridors of Influence in the Dissemination of Customer-Oriented Strategy to Customer Contact Service Employees. *Journal of Marketing*, *64*(2), 35–50.

Hatchuel, A., Le Masson, P., & Weil, B. (2001). From R&D to R-I-D: Design Strategies and the Management of Innovation Fields. In *8th International Product Development Management Conference* (pp. 1–16). Enschede.

He, Z.-L., & Wong, P.-K. (2004). Exploration vs. Exploitation: An Empirical Test of the Ambidexterity Hypothesis. *Organization Science*, *15*(4), 481–494.

Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M. A., Singh, H., Teece, D. J., & Winter, S. G. (2007). *Dynamic Capabilities - Understanding Strategic Change in Organizations*. Oxford: Blackwell Publishing.

Helfat, C. E., & Peteraf, M. (2003). The Dynamic Resource-Based View: Capability Lifecycles. *Strategic Management Journal*, *24*(10), 997–1010.

Henard, D. H., & Szymanski, D. M. (2001). Why Some New Products Are More Successful Than Others. *Journal of Marketing Research*, *38*(3), 362–375.

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quartely*, *35*, 9–30.

Henderson, R. M., & Cockburn, I. (1996). Scale, Scope, and Spillovers: the Determinants of Research Productivity in Drug Discovery. *The Rand Journal of Economics*, *27*(1), 32–59.

Herstatt, C. (2002). Search Fields for Radical Innovations Involving Market Research. *International Journal of Entrepreneurship and Innovation Management*, *2*(6), 1–11.

Herstatt, C., Lüthje, C., & Lettl, C. (2001). *Innovation Search Fields with Lead Users* (No. 9e). Hamburg.

Herstatt, C., & Verworn, B. (2004). The “Fuzzy Front End” of innovation. In European Institute for Technology and Innovation Management (Ed.), *Bringing Technology and Innovation into the Boardroom* (pp. 347–372). Hampshire: Palgrave Macmillan.

Hertenstein, J. H., & Platt, M. B. (2000). Performance Measures and Management Control in New Product Development. *Accounting Horizons*, *14*(3), 303–319.

Hitt, M. A., Ricarti Costa, J., & Nixon, R. D. (1998). The New Frontier. In M. A. Hitt (Ed.), *Managing Strategically in an Interconnected World* (pp. 1–13). Chicester: John Wiley & Sons.

Hoegl, M., & Parboteeah, P. K. (2007). Creativity in Innovative Projects: How Teamwork Matters. *Journal of Engineering and Technology Management*, *24*(1–2), 148–166.

Horton, N. J., & Kleinman, K. P. (2007). Much Ado About Nothing: A Comparison of Missing Data Methods and Software to Fit Incomplete Data Regression Models. *The American Statistician*, *61*(1), 79–90.

Horton, N. J., & Lipsitz, S. R. (2001). Multiple Imputation in Practice: Comparison of Software Packages for Regression Models with Missing Variables. *The American Statistician*, *55*(3), 244–254.

Hult, G. T. M., Hurley, R. F., & Knight, G. A. (2004). Innovativeness: Its Antecedents and Impact on Business Performance. *Industrial Marketing Management*, *33*, 429–438.

Hunt, S. D., Sparkman, R. D., & Wilcox, J. B. (1982). The Pretest in Survey Research: Issues and Preliminary Findings. *Journal of Marketing Research*, *19*(2), 269–273.

Hüsig, S., & Kohn, S. (2003). Factors Influencing the Front End of the Innovation Process: A Comprehensive Review of Selected Empirical NPD and Explorative FFE Studies. In *10th International Product Development Management Conference* (pp. 1–21). Brussels.

Hüsig, S., Kohn, S., & Poskela, J. (2005). The Role of Process Formalisation in the Early Phases. In *12th International Product Development Management Conference* (pp. 857–872). Copenhagen.

Ibrahim, J. G., Chen, M.-H., Lipsitz, S. R., & Herring, A. H. (2005). Missing-Data Methods for Generalized Linear Models. *Journal of the American Statistical Association*, *100*(469), 332–346.

IoT Analytics. (2015). IoT Company Ranking. Retrieved May 3, 2017, from http://iot-analytics.com/wp/wp-content/uploads/2016/01/Ranking-IoT-companies-Q3-Q4-2015-Dec-2015-v6.pdf

Iyer, B. (2016). To Predict the Trajectory of the Internet of Things, Look to the Software Industry. Retrieved May 3, 2017, from https://hbr.org/2016/02/to-predict-the-trajectory-of-the-internet-of-things-look-to-the-software-industry

Jackson, J. D., Yi, M. Y., & Park, J. S. (2013). An Empirical Test of Three Mediation Models for the Relationship between Personal Innovativeness and User Acceptance of Technology. *Information & Management*, *50*(4), 154–161.

Jansen, J. J. P., Tempelaar, M. P., van den Bosch, F. A. J., & Volberda, H. W. (2009). Structural Differentiation and Ambidexterity: The Mediating Role of Integration Mechanisms. *Organization Science*, *20*(4), 797–811.

Jansen, J. J. P., Van Den Bosch, F. A. J., & Volberda, H. W. (2005). Exploratory Innovation, Exploitative Innovation, and Ambidexterity: The Impact of Environmental and Organizational Antecedents. *Schmalenbach Business Review*, *57*(4), 351–363.

Jansen, J. J. P., Van Den Bosch, F. A. J., & Volberda, H. W. (2006). Exploratory Innovation , Exploitative Innovation , and Performance: Effects of Organizational Antecedents and Environmental Moderators. *Management Science*, *52*(11), 1661–1674.

Jaruzelski, B., Loehr, J., & Holman, R. (2012). The Global Innovation 1000: Making Ideas Work. *Strategy + Business*, *18*(69), 1–14.

Jaruzelski, B., Staack, V., & Schwartz, K. (2015). 2015 Global Innovation 1000. Retrieved July 20, 2017, from https://www.strategyand.pwc.com/media/file/2015-Global-Innovation-1000-Fact-Pack.pdf

Jaworski, B. J., & Kohli, A. K. (1993). Market Orientation: Antecedents and Consequences. *Journal of Marketing*, *57*(July), 53–70.

Jensen, R. M. (2008). Staging Exchange Partner Choices: When Do Status and Reputation Matter? *Academy of Management Journal*, *51*(3), 495–516.

Jick, T. D. (1979). Mixing Qualitative and Quantitative Methods: Triangulation in Action. *Administrative Science Quarterly*, *24*(4), 602–611.

Jiménez-Jiménez, D., & Sanz-Valle, R. (2011). Innovation, Organizational Learning, and Performance. *Journal of Business Research*, *64*(4), 408–417.

John, G., & Martin, J. (1984). Effects of Organizational Structure of Marketing Planning on Credibility and Utilization of Plan Output. *Journal of Marketing Research*, *21*(2), 170–183.

Johnson, B., Onwuegbuzie, A., & Turner, L. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, *1*(2), 112–133.

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing the Business Model. *Harvard Business Review*, *87*(12), 52–60.

Jonash, R. S., & Sommerlatte, T. (1999). The Innovation Premium: Capturing the Value of Creativity. *Prism*, *10*(3), 5–25.

Jonash, R., & Sommerlatte, T. (1999). *The Innovation Premium*. New York: Perseus Book Group.

Judge, W. Q., & Blocker, C. P. (2008). Organizational Capacity for Change and Strategic Ambidexterity: Flying the Plane while Rewiring it. *European Journal of Marketing*, *42*(9/10), 915–926.

Kahn, K. B., Franzak, F., & Griffin, A. (2003). Editorial: Identification and Consideration of Emerging Research Questions. *Journal of Product Innovation Management*, *20*(3), 193–201.

Katila, R., & Ahuja, G. (2002). Something Old, Something New: A Longitudinal Study of Search Behaviour and New Product Introduction. *Academy of Management Journal*, *45*(6), 1183–1194.

Kelley, T. (2001). *The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm*. New York: Doubleday Publishing Group.

Keupp, M. M., Palmie, M., & Gassmann, O. (2013). The Strategic Management of Innovation: A Systematic Review and Paths for Future Research. *International Journal of Management Reviews*, *14*(4), 367–390.

Khurana, A., & Rosenthal, S. R. (1997). Integrating the Fuzzy Front End of New Product Development. *Sloan Management Review*, *38*(2), 103–120.

Khurana, A., & Rosenthal, S. R. (1998). Towards Holistic "Front Ends" in New Product Development. *Journal of Product Innovation Management*, *15*(1), 57–74.

Kim, C., Song, J., & Nerkar, A. (2012). Learning and Innovation: Exploitation and Exploration Trade-offs. *Journal of Business Research*, *65*(8), 1189–1194.

Kim, J., & Wilemon, D. (2002a). Focusing the Fuzzy Front-End in New Product Development. *R&D Management*, *34*(4), 269–279.

Kim, J., & Wilemon, D. (2002b). Strategic Issues in Managing Innovation's Fuzzy Front-End. *European Journal of Innovation Management*, *5*(1), 27–39.

Kimberly, J. R., & Evanisko, M. J. (1981). Organizational Innovation: The Influence of Individual, Organizational and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations. *Academy of Management Journal1*, *24*(4), 689–713.

Kleinigham, T. L., Aksoy, L., Cooil, B., & Andreassen, T. W. (2008). Linking Customer Loyalty to Growth. *MIT Sloan Management Review*, *49*(4), 51–57.

Kleinschmidt, E. J., & Cooper, R. G. (1991). The Impact of Product Innovativeness on Performance. *Journal of Product Innovation Management*, *8*(4), 240–251.

Kleinschmidt, E. J., De Brentani, U., & Salomo, S. (2007). Performance of Global New Product Development Programs. *Journal of Product Innovation Management*, *24*(5), 419–441.

Kock, A., Heising, W., & Gemünden, H. G. (2015). How Ideation Portfolio Management Influences Front-End Success. *Journal of Product Innovation Management*, *32*(4), 539–555.

Koen, P., Ajamian, G., Burkart, R., Clamen, A., Davidson, J., D'Amore, R., … Wagner, K. (2001). Providing Clarity and a Common Language to the Fuzzy Front End. *Research Technology Management*, *44*(2), 46–55.

Koen, P., Ajamian, G. M., Boyce, S., Clamen, A., Fisher, E., Fountoulakis, S., … Seibert, R. (2002). Fuzzy Front End: Effective Methods, Tools, and Techniques. In P. Belliveau, A. Griffin, & S. Somermeyer (Eds.), *The PDMA ToolBook for New Product Development (Product Development and Management ToolBooks)* (pp. 5–35). Hoboken: Wiley.

Koen, P., & Bertels, H. (2010). The Front End of Innovation in Large Established Firms. In V. K. Narayanan & G. Colarelli O'Connor (Eds.), *Encyclopedia of Technology and Innovation Management* (pp. 233–239). West Sussex: Wiley & Sons.

Koen, P., Bertels, H., & Kleinschmidt, E. J. (2014). Managing the Front End of Innovation - Part I. *Research Technology Management*, *57*(2), 34–43.

Kohli, A. K., & Jaworski, B. J. (1990). Market Orientation: The Construct, Research Propositions, and Managerial Implications. *Journal of Marketing*, *54*(2), 1–18.

Kowarik, A., & Templ, M. (2016). Imputation with the R Package VIM. *Journal of Statistical Software*, *74*(7), 1–16.

Kramer, F. (1977). *Produktinnovation: Der Weg zur Gewinnung und Sicherung von Marktanteilen*. Bern: Schweizerische Volksband.

Kratzer, J., Leenders, R. T., Van Engelen, J. M., & Kunst, L. (2007). *Innovationnet: The Art of Creating and Benefiting from Innovation Networks*. Assen: Royal Van Gorcum.

Kyriakopoulos, K., & Moorman, C. (2004). Tradeoffs in Marketing Exploitation and Exploration Strategies: The Overlooked Role of Market Orientation. *International Journal of Research in Marketing*, *21*(3), 219–240.

Lance, C. E., Butts, M. M., & Michels, L. C. (2006). The Sources of Four Commonly Reported Cutoff Criteria - What Did They Really Say? *Organizational Research Methods*, *9*(2), 202–220.

Laurie, D., Doz, Y., & Sheer, C. (2006). Creating New Growth Platforms. *Harvard Business Review*, *84*(5), 80–90.

Lee, K., Woo, H.-G., & Joshi, K. (2017). Pro-Innovation Culture, Ambidexterity and New Product Development Performance: Polynomial Regression and Response Surface Analysis. *European Management Journal*, *35*(2), 249–260.

Legnick-Hall, C. A. (1992). Innovation and Competitive Advantage: What We Know and What We Need to Learn. *Journal of Management*, *18*(2), 399–429.

Leifer, R., McDermott, C., & Colarelli O'Connor, G. (2000). *Radical Innovation: How Mature Companies Can Outsmart Upstarts*. Boston (MA): Harvard Business School Press.

Levinthal, D. A., & March, J. G. (1981). A Model of Adaptive Organizational Search. *Journal of Economic Behaviour and Organization*, *2*(4), 307–333.

Levinthal, D. A., & March, J. G. (1993). The Myopia of Learning. *Strategic Management Journal*, *14*, 95–112.

Levitt, B., & March, J. G. (1988). Organizational Learning. *Annual Review of Sociology*, *14*, 319–340.

Lewin, K. (1936). *Principles of Topological Psychology*. New York: McGraw-Hill.

Li, H., & Atuahene-Gima, K. (2001). Product Innovation Strategy and the Performance of New Technology Ventures in China. *Academy of Management Journal*, *44*(6), 1123–1134.

Lichtenthaler, E. (2004). Technological Change and the Technology Intelligence Process: A Case Study. *Journal of Engineering and Technology Management*, *21*(4), 331–348.

Lichtenthaler, E., & Savioz, P. (2004). Organisation of the Early Phases of the Radical Innovation Process. *International Journal of Technology Intelligence and Planning*, *1*(1), 100–114.

Liebl, F., & Schwarz, J. O. (2010). Normality of the Future: Trend Diagnosis for Strategic Foresight. *Futures*, *42*(4), 313–327.

Lin, X., & Germain, R. (2003). Organizational Structure, Context, Customer Orientation, and Performance: Lessons from Chinese State-Owned Enterprises. *Strategic Management Journal*, *24*(11), 1131–1151.

Little, R. J. A. (1988). Missing-Data Adjustments in Large Surveys. *Journal of Business & Economic Statistics*, *6*(3), 287–296.

Luca, L. M. De, Verona, G., & Vicari, S. (2010). Market Orientation and R&D Effectiveness in High-Technology Firms: An Empirical Investigation in the Biotechnology Industry. *Journal of Product Innovation Management*, *27*(3), 299–320.

Lucas, H. C., & Goh, J. M. (2009). Disruptive Technology: How Kodak missed the Digital Photography Revolution. *Journal of Strategic Information Systems*, *18*(1), 46–55.

Luhmann, M. (2015). *R für Einsteiger* (4th ed.). Weinheim: Beltz.

Lynn, G. S., Morone, J., & Paulson, A. S. (1996). Marketing and Discontinuous Innovation: The Probe and Learn Process. *California Management Review*, *38*(3), 8–37.

Malhotra, N. K. (2006). Questionnaire Design and Scale Developmen. In R. Grover & M. Vriens (Eds.), *The Handbook of Marketing Research* (pp. 83–94). Thousand Oaks: Sage Publications.

Manyika, J., Chui, M., Bisson, P., Woetzel, J., Dobbs, R., Bughin, J., & Aharon, D. (2015). The Internet of Things: Mapping the Value beyond the Hype. Retrieved May 3, 2017, from http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world

March, J. G. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science*, *2*(1), 71–87.

Markham, S. K. (2013). The Impact of Front-End Innovation Activities on Product Performance. *Journal of Product Innovation Management*, *30*(S1), 77–92.

Martinsuo, M., & Poskela, J. (2011). Use of Evaluation Criteria and Innovation Performance in the Front End of Innovation. *Journal of Product Innovation Management*, *28*(6), 896–914.

Mathews, S. (2010). Innovation Portfolio Architecture. *Research Technology Management*, *53*(6), 30–40.

Maxwell, J. (2005). *Qualitative Research Design: An Interactive Approach* (2nd ed.). Thousand Oaks: Sage Publications.

Maxwell, J. (2013). *Qualitative Research Design: An Interactive Approach* (3rd ed.). Thousand Oaks: Sage Publications.

Mayer, M. A. (2006). Creativity Loves Constraints. Retrieved June 26, 2012, from http://www.businessweek.com/magazine/content/06_07/b3971144.htm

McKee, D. (1992). An Organizational Learning Approach to Product Innovation. *Journal of Product Innovation Management*, *9*(3), 232–245.

Meermeyer, M. (2014). LinRegInteractive: An R Package for the Interactive Interpretation of Linear Regression Models [Computer Software]. *Schumpeter Discussion Papers*, *14*, 1–22.

Michelfelder, I., & Kratzer, J. (2013). Why and How Combining Strong and Weak Ties within a Single Interorganizational R&D Collaboration Outperforms Other Collaboration Structures. *Journal of Product Innovation Management*, *30*(6), 1159–1177.

Miles, M. B., & Huberman, M. A. (1994). *Qualitative Data Analysis: An Expanded Sourcebook* (2nd ed.). Thousand Oaks: Sage Publications.

Miles, R. E., Snow, C. C., Meyer, A. D., & Coleman, H. J. (1978). Organizational Strategy, Structure and Process. *The Academy of Management Review*, *3*(3), 546–562.

Mishra, S., Kim, D., & Lee, D. H. (1996). Factors Affecting New Product Success: Cross-Country Comparisons. *Journal of Product Innovation Management*, *13*(6), 530–550.

Moenart, R. K., De Meyer, A., Souder, W., & Deschoolmeester, D. (1995). R&D/Marketing Communication During the Fuzzy Front-End. *IEEE Transactions on Engineering Management*, *42*(3), 243–258.

Montoya-Weiss, M. M., & Calantone, R. (1994). Determinants of New Product Performance: A Review and Meta-Analysis. *Journal of Product Innovation Management*, *11*(5), 397–417.

Montoya-Weiss, M. M., & O'Driscoll, T. M. (2000). From Experience: Applying Performance Support Technology in the Fuzzy Front End. *Journal of Product Innovation Management*, *17*(2), 143–161.

Mootee, I. (2011). Strategic Innovation and the Fuzzy Front End. *Ivey Business Journal*, *12*(2), 44–50.

Müller-Stewens, G. (1986). *Strategische Suchfeldanalyse*. (G. Schuh & S. Klappert, Eds.), *Technologiemanagement - Handbuch Produktion und Management 2* (2nd ed.). Wiesbaden: Gabler Verlag.

Murphy, S., & Vinod, K. (1997). The Front End of New Product Development. *R&D Management*, *27*(1), 5–15.

Murray, A., Papa, A., Cuozzo, B., & Russo, G. (2016). Evaluating the Innovation of the Internet of Things. *Business Process Management*, *22*(2), 341–356.

Nag, R., Hambrick, D. D., & Chen, M.-J. (2007). What is Strategic Management, Really? Inductive Derivation of a Consensus Definition of the Field. *Strategic Management Journal*, *28*(9), 935–955.

Narver, J. C., & Slater, S. F. (1990). The Effect of a Market Orientation on Business Profitability. *Journal of Marketing*, *54*(4), 20–35.

Nelson, R. R., & Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge: Belknap Press.

Neter, J., Wasserman, W., & Kutner, M. H. (1985). *Applied Linear Statistical Models: Regression, Analysis of Variance, and Experimental Design*. Homewood (IL): Richard D Irwin.

Nobelius, D., & Trygg, L. (2002). Stop Chasing the Front End process - Management of the Early Phases in Product Development Projects. *International Journal of Project Management*, *20*(5), 331–340.

Noble, C. H., & Mokwa, M. P. (1999). Implementing Marketing Strategies: Developing and Testing a Managerial Theory. *Journal of Marketing*, *63*(4), 57–73.

Noble, C. H., Sinha, R. K., & Kumar, A. (2002). Market Orientation and Alternative Strategic Orientations: A Longitudinal Assessment of Performance Implications. *Journal of Marketing*, *66*(4), 25–39.

Normann, R. (1985). Developing Capabilities for Organizational Learning. In J. M. Pennings (Ed.), *Organizational Strategy and Change: New Viewpoints on Formulating and Implementing Strategic Decisions*. San Francisco: Jossey-Bass.

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.

Nyffenegger, F., Jamali, N., Kobe, C., & Meier, M. (2005). Towards an IT Supported Fuzzy Front End of Product Development. In *International Conference on Engineering Design* (pp. 437–451). Melbourne.

O'Cass, A., Heirati, N., & Ngo, L. V. (2014). Achieving New Product Success via the Synchronization of Exploration and Exploitation across Multiple Levels and Functional Areas. *Industrial Marketing Management*, *43*(5), 862–872.

O'Reilly, C. A., & Tushman, M. L. (2008). Ambidexterity as a Dynamic Capability: Resolving the Innovator's Dilemma. *Research in Organizational Behavior*, *28*, 185–206.

OECD - Statistical Office of the European Communities. (2005). *Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data* (3rd ed.). Paris: OECD Publishing.

Oliveira, M. G., & Rozenfeld, H. (2010). Integrating Technology Roadmapping and Portfolio Management at the Front-End of New Product Development. *Technological Forecasting and Social Change*, *77*(8), 1339–1354.

Onwuegbuzie, A. J., & Johnson, B. (2006). The Validity Issue in Mixed Research. *Research in the Schools*, *13*(1), 48–63.

Osterwald, A., & Pigneur, Y. (2010). *Business Model Generation* (1st ed.). Hoboken (NJ): John Wiley & Sons.

Paladino, A. (2007). Investigating the Drivers of Innovation and New Product Sucess: A Comparison of Strategic Orientations. *Journal of Product Innovation Management*, *24*(6), 534–553.

Paliokaite, A., & Pačesa, N. (2015). The Relationship between Organisational Foresight and Organisational Ambidexterity. *Technological Forecasting and Social Change*, *101*, 165–181.

Paluch, S., & Wunderlich, N. V. (2016). Contrasting Risk Perceptions of Technology-Based Service Innovations in Inter-Organizational Settings. *Journal of Business Research*, *69*(7), 2424–2431.

Perkins, D. N. (1981). *The Mind's Best Work*. London: Harvard University Press.

Persaud, A. (2005). Enhancing Synergistic Innovative Capability in Multinational Corporations: An Empirical Investigation. *Journal of Product Innovation Management*, *22*(5), 412–429.

Pfeiffer, S. (1992). *Technologie-Frühaufklärung. Identifikation und Bewertung zukünftiger Technologien in der strategischen Unternehmensplanung*. (G. Schuh & S. Klappert, Eds.), *Technologiemanagement - Handbuch Produktion und Management 2*. Berlin: Steuer- und Wirtschaftsverlag.

Piekkari, R., Welch, C., & Paavilainen, E. (2009). The Case Study as Disciplinary Convention - Evidence from International Business Journals. *Organizational Research Methods*, *12*(3), 567–589.

Pinto, J. K. (2002). Project Management 2002. *Research Technology Management*, *45*(2), 22–37.

Pisano, G. P. (2015). You Need an Innovation Strategy. *Harvard Business Review*, *93*(6), 44–54.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. *The Journal of Applied Psychology*, *88*(5), 879–903.

Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of Method Bias in Social Science Research and Recommendations on How to Control It. *Annual Review of Psychology*, *63*(1), 539–569.

Poetz, M. K., & Prügl, R. (2010). Crossing Domain-Specific Boundaries in Search of Innovation: Exploring the Potential of Pyramiding. *The Journal of Product Innovation Management*, *27*(6), 897–914.

Pook, M., Tuschen-Caffier, B., & Kaufmann, U. (2006). Has the Translation Process Impact on the Psychometric Strucuture of a Questionnaire? - A Comparison of Two German Versions of the Eating Disorder Inventory. *Psychother Psych Med*, *56*(9–10), 397–402.

Porter, M. (2008). The Five Competitive Forces that Shape Strategy [Special Issue on HBS Centennial]. *Harvard Business Review*, *86*(1), 78–93.

Posen, H. E., & Levinthal, D. A. (2012). Chasing a Moving Target: Exploitation and Exploration in Dynamic Environments. *Management Science*, *58*(3), 587–601.

Poskela, J., & Martinsuo, M. (2009). Management Control and Strategic Renewal in the Front End of Innovation. *Journal of Product Innovation Management*, *26*(6), 671–684.

Racela, O. C. (2014). Customer Orientation, Innovation Competencies, and Firm Performance: A Proposed Conceptual Model. *Procedia - Social and Behavioral Sciences*, *148*, 16–23.

Raisch, S., & Birkinshaw, J. (2008). Organizational Ambidexterity: Antecedents, Outcomes, and Moderators. *Journal of Management*, *34*(3), 375–409.

Raisch, S., Birkinshaw, J., Probst, G., & Tushman, M. L. (2009). Organizational Ambidexterity: Balancing Exploitation and Exploration for Sustained Performance. *Organization Science*, *20*(4), 685–695.

Reckase, M. D., & McKinley, R. L. (1991). The Discriminating Power of Items That Measure More Than One Dimension. *Applied Psychological Measurement*, *15*(4), 361–373.

Reid, S. E., & de Brentani, U. (2004). The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model. *The Journal of Product Innovation Management*, *21*(3), 170–184.

Rein, G. L. (2004). From Expericence: Creating Synergy between Marketing and Research and Development. *Journal of Product Innovation Management*, *21*(1), 33–43.

Reinertsen, D. G. (1999). Taking the Fuzziness out of the Fuzzy Front End. *Research Technology Management*, *42*(6), 25–31.

Revelle, W. (2017). Principal Components Analysis (PCA). Retrieved January 6, 2017, from http://www.personality-project.org/r/html/principal.html

Ries, E. (2011). *The Lean Startup*. New York: Crown Publishing.

Ringel, M., Taylor, A., & Zablit, H. (2015). The Most Innovative Companies 2015 (BCG Report). Retrieved August 8, 2016, from https://www.bcgperspectives.com/content/articles/growth-lean-manufacturing-innovation-in-2015/

Robson, C. (2002). *Real World Research* (2nd ed.). Oxford: Blackwell Publishing.

Rocco, T., Bliss, L., Gallagher, S., & Pérer-Prado, A. (2003). Taking the Next Step: Mixed Methods Research in Organizational Systems. *Information Technology, Learning, and Performance Journal*, *21*(1), 19–29.

Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). New York: Free Press.

Rosenkopf, L., & Nerkar, A. (2001). Beyond Local Search: Boundary-Spanning, Exploration and Impact in the Optical Disk Industry. *Strategic Management Journal*, *22*(4), 287–306.

Rosso, B. D. (2014). Creativity and Constraints: Exploring the Role of Constraints in the Creative Processes of Research and Development Teams. *Organization Studies*, *35*(4), 551–585.

Ruekert, R. W., Walker, O. C. J., & Roering, K. J. (1985). The Organization of Marketing Activities: A Contingency Theory of Structure and Performance. *Journal of Marketing*, *49*, 13–26.

Russell, R. K., & Tippett, D. D. (2008). Critical Success Factors for the Fuzzy Front End of Innovation in the Medical Device Industry. *Engineering Management Journal*, *20*(3), 36–43.

Salomo, S., Gemünden, H. G., & Leifer, R. (2007). Research on Corporate Radical Innovation Systems - A Dynamic Capabilities Perspective: An Introduction. *Journal of Engineering and Technology Management*, *24*(1–2), 1–10.

Salomo, S., Talke, K., & Strecker, N. (2008). Innovation Field Orientation and Its Effect on Innovativeness and Firm Performance. *Journal of Product Innovation Management*, *25*(6), 560–576.

Santos-Vijande, M. L., & Álvarez-González, L. I. (2007). Innovativeness and Organizational Innovation in Total Quality Oriented Firms: The Moderating Role of Market Turbulence. *Technovation*, *27*(9), 514–532.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students* (5th ed.). Harlow: Prentice Hall International.

Schiele, H. (2006). How to Distinguish Innovative Suppliers? Identifying Innovative Suppliers as New Task for Purchasing. *Industrial Marketing Management*, *35*(8), 925–935.

Schmitdt, J., & Calantone, R. J. (1998). Are Really New Product Development Projects Harder To Shut Down? *Journal of Product Innovation Management*, *15*(2), 111–123.

Scholz, R. W., & Tetje, O. (2002). *Embedded Case Study Methods: Integrating Quantitative and Qualitative Knowledge*. Thousand Oaks: Sage Publications.

Schuh, G., Orilski, S., & Wellensiek, M. (2009). Efficient Technology Intelligence by Search Field Strategies. In *International Society for Professional Innovation Management: The XX ISPIM Conference*. Wien.

Schultz, C., Salomo, S., de Brentani, U., & Kleinschmidt, E. J. (2013). How Formal Control Influences Decision-Making Clarity and Innovation Performance. *Journal of Product Innovation Management*, *30*(3), 430–447.

Schumpeter, J. A. (1934). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle* (16th ed.). New Brunswick: Transaction Publishers.

Schumpeter, J. A. (1939). *Business Cycles - A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. New York: McGraw-Hill.

Sethi, R., & Iqbal, Z. (2008). Stage-Gate Controls, Learning Failure, and Adverse Effect on Novel New Products. *Journal of Marketing*, *72*(1), 118–134.

Shalley, C. E., & Gilson, L. L. (2004). What Leaders Need to Know: A Review of Social and Contextual Factors that Can Foster or Hinder Creativity. *Leadership Quarterly*, *15*(1), 33–53.

Sheehan, K. B. (2001). E-Mail Survey Response Rates: A Review. *Journal of Computer-Mediated Communication*, *6*(2).

Sheremata, W. a. (2000). Centrifugal and Centripetal Forces in Radical New Product Development under Time Pressure. *Academy of Management Review*, *25*(2), 389–408.

Shrivastava, P., & Grant, J. H. (1985). Empirically Derived Models of Strategic Decision Making. *Strategic Management Journal*, *6*(2), 97–113.

Siggelkow, N., & Levinthal, D. A. (2003). Temporarily Divide to Conquer: Centralized, Decentralized, and Reintegrated Organizational Approaches to Exploration and Adaptation. *Organization Science*, *14*(6), 650–669.

Slater, S. F., & Narver, J. C. (1998). Customer-Led and Market Oriented: Let's not Confuse the Two. *Strategic Management Journal*, *19*(10), 1001–1006.

Smith, D. (2006). *Exploring Innovation*. Berkshire: McGraw-Hill.

Smith, K. A., Vasudevan, S. P., & Tanniru, M. R. (1996). Organizational Learning and Resource-Based Theory: An Integrative Model. *Journal of Organizational Change Management*, *9*(6), 41–53.

Smith, P., & Reinertsen, D. (1991). *Developing Products in Half the Time*. New York: Van Nostrand.

Spanjol, J., Rosa, A., & Qualls, W. J. (2011). How Many and What Kind? The Role of Strategic Orientation in New Product Ideation. *Journal of Product Innovation Management*, *28*(2), 236–250.

Staack, V., Huff Eckert, V., Cole, B., & Riggs, J. B. (2017). Reinventing Innovation: Five Findings to Guide Strategy through Execution. Retrieved July 20, 2017, from www.pwc.com/innovation-benchmark

Talke, K., Salomo, S., & Rost, K. (2010). How Top Management Team Diversity Affects Innovativeness and Performance via the Strategic Choice to Focus on Innovation Fields. *Research Policy*, *39*(7), 907–918.

Tashakkori, A., & Teddlie, C. (2003). *Handbook of Mixed Methods in Social and Behavioral Research*. Thousand Oaks: Sage Publications.

Tatikonda, M. V, & Rosenthal, S. R. (2000). Successful Execution of Product Development Projects: Balancing Firmness and Flexibility in the Innovation Process. *Journal of Operations Management*, *18*(4), 401–425.

Taylor, A., & Greve, H. R. (2016). Superman or The Fantastic Four? Knowledge Combination and Experience in Innovative Teams. *Academy of Management Journal*, *49*(4), 723–740.

Teece, D. J. (2007). Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance. *Strategic Management Journal*, *28*(13), 1319–1350.

Teller, J., Unger, B. N., Kock, A., & Gemünden, H. G. (2012). Formalization of Project Portfolio Management: The Moderating Role of Project Portfolio Complexity. *International Journal of Project Management*, *30*(5), 596–607.

Teo, T. (2013). *Handbook of Quantitative Methods for Educational Research*. Rotterdam: Sense Publishers.

Thompson, L. (2003). Improving the Creativity of Organizational Work Groups. *Academy of Management Executive*, *17*(1), 96–109.

Tidd, J. (2001). Innovation Management in Context: Environment, Organization and Performance. *International Journal of Management Reviews*, *3*(3), 169–183.

Tidd, J., & Bessant, J. (2001). *Managing Innovation: Integrating Technological, Market and Organizational Change* (5th ed.). Hoboken: John Wiley & Sons.

Trott, P. (2008). *Innovation Management and New Product Development* (4th ed.). Essex: Pearson Education.

Trotter, P. J. (2011). A New Modified Total Front End Framework for Innovation: New Insights from Health Related Industries. *International Journal of Innovation Management*, *15*(5), 1013–1041.

Tsai, K. H., & Yang, S. Y. (2013). Firm Innovativeness and Business Performance: The Joint Moderating Effects of Market Turbulence and Competition. *Industrial Marketing Management*, *42*(8), 1279–1294.

Tuominen, M., Rajala, A., & Möller, K. (2004). How Does Adaptability Drive Firm Innovativeness? *Journal of Business Research*, *57*(5), 495–506.

Tushman, M. L. (1977). Special Boundary Roles in the Innovation Process. *Administrative Science Quarterly*, *22*(4), 578–605.

Tushman, M. L., & O'Reilly, C. A. (1996). Ambidextrous Organization: Managing Evolutionary and Revolutionary Change. *California Management Review*, *38*(4), 8–30.

Tushman, M. L., & Scanlan, T. (1981). Boundary Spanning Individuals: Their Role in Information Transfer and Their Antecedents. *The Academy of Management Journal*, *24*(2), 289–305.

UCLA: Statistical Consulting Group. (2017). Interpretation of Quadratic Terms in Polynomial Regressions. Retrieved January 6, 2017, from https://stats.idre.ucla.edu/other/mult-pkg/faq/general/faqhow-do-i-interpret-the-sign-of-the-quadratic-term-in-a-polynomial-regression/

van Buuren, S. (2017). Package "MICE" - Multivariate Imputation by Chained Equations [Computer Program]. Retrieved from http://www.jstatsoft.org/v45/i03/

van Buuren, S., & Groothuis-Oudshoorn. (2011). Mice: Multivariate Imputation by Chained Equations in R. *Journal of Statistical Software*, *45*(3), 1–67.

van de Ven, A. H. (2017). The Innovation Journey: You Can't Control It, but You Can Learn to Meneuvre It. *Innovation: Organization & Management*, *19*(1), 39–42.

Vanderstoep, S. W., & Johnston, D. D. (2008). *Research Methods for Everyday Life - Blending Qualitative and Quantitative Approaches*. San Francisco: Jossey-Bass.

VDI. (1980). *Produktplanung - Ablauf, Begriffe und Organisation - VDI 2220*. Düsseldorf: VDI.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, *46*(2), 186–204.

Verganti, R. (1999). Planned Flexibility: Linking Anticipation and Reaction in Product Development Projects. *Journal of Product Innovation Management*, *16*(4), 363–376.

Verworn, B., Herstatt, C., & Nagahira, A. (2008). The Fuzzy Front End of Japanese New Product Development Projects: Impact on Success and Differences Between Incremental and Radical Projects. *R&D Management*, *38*(1), 1–18.

Vincente-Oliva, S., Martínez-Sánchez, À., & Berges-Muro, L. (2016). Enhancing the Outcomes in R&D Collaborative Projects: An Empirical Analysis of the Middle Ebro Valley in Spain. *International Journal of Innovation Management*, *20*(7), 1–34.

Vissak, T. (2010). Recommendations for Using the Case Study Method in International Business Research. *The Qualitative Report*, *15*(2), 370–388.

Vuori, T. O., & Huy, Q. N. (2016). Distributed Attention and Shared Emotions in the Innovation Process: How Nokia Lost the Smartphone Battle. *Administrative Science Quarterly*, *61*(1), 9–51.

Waldman, D. A., & Bass, B. M. (1991). Transformational Leadership at Different Phases of the Innovation Process. *Journal of High Technology Management Research*, *2*(2), 169–180.

Wangpipatwong, S., Chutimaskul, W., & Papasratorn, B. (2008). Understanding Citizen' s Continuance Intention to Use e-Government Website: A Composite View of Technology Acceptance Model and Computer Self-Efficacy. *The Electronic Journal of E-Government*, *6*(1), 55–64.

Weerawardena, J. (2003). The Role of Marketing Capability in Innovation-Based Competitive Strategy. *Journal of Strategic Marketing*, *11*(1), 15–35.

Wei, Y., O'Neill, H., Lee, R. P., & Zhou, N. (2012). The Impact of Innovative Culture on Individual Employees: The Moderating Role of Market Information Sharing. *Journal of Product Innovation Management*, *30*(5), 1027–1041.

Wei, Z., Yi, Y., & Guo, H. (2014). Organizational Learning Ambidexterity, Strategic Flexibility, and New Product Development. *Journal of Product Innovation Management*, *31*(4), 832–847.

Wei, Z., Yi, Y., & Yuan, C. (2011). Bottom-Up Learning, Organizational Formalization, and Ambidextrous Innovation. *Journal of Organizational Change Management*, *24*(8), 314–329.

Wei, Z., Zhao, J., & Zhang, C. (2014). Organizational Ambidexterity, Market Orientation, and Firm performance. *Journal of Engineering and Technology Management*, *33*, 134–153.

Wellensiek, M., Orilski, S., & Schuh, G. (2009). Efficient Technology Intelligence by Search Field Strategies. In *The XX ISPIM Conference 21 - 24 June* (pp. 1–15). Vienna.

Wellers, D. (2015). Is this the future of the Internet of Things? Retrieved July 21, 2017, from https://www.weforum.org/agenda/2015/11/is-this-future-of-the-internet-of-things/

Wheelwright, S. C., & Clark, K. B. (1992). Creating Project Plans to Focus Product Development. *Harvard Business Review*, *70*(2), 70–83.

World Economic Forum. (2014). Industrial Internet of Things: Unleashing the Potential of Connected Products and Services. Retrieved August 1, 2017, from http://reports.weforum.org/industrial-internet-of-things/

Yigitcanlar, T., Sabatini-Marques, J., Da-Costa, E. M., Kamruzzaman, M., & Ioppolo, G. (2017). Stimulating Technological Innovation Through Incentives: Perceptions of Australian and Brazilian Firms. *Technological Forecasting and Social Change*, *in press*, 1–10.

Yin, R. K. (2014). *Case Study Research - Design and Methods* (5th ed.). Thousand Oaks: Sage Publications.

Zahay, D., Griffin, A., & Fredericks, E. (2004). Sources, Uses, and Forms of Data in the New Product Development pProcess. *Industrial Marketing Management*, *33*, 657–666.

Zahra, S. A. (1993). Environment, Corporate Entrepreneurship, and Financial Performance: A Taxonomic Approach. *Journal of Business Venturing*, *8*(4), 319–340.

Zahra, S. A., & Covin, J. G. (1993). Business Strategy, Technology Policy and Firm Performance. *Strategic Management Journal*, *14*(6), 451–478.

Zaltman, G., Duncan, R., & Holbek, J. (1973). *Innovations and Organizations*. New York: John Wiley and Sons.

Zhang, Q., & Doll, W. J. (2001). The Fuzzy Front End and Success of New Product Development: A Causal Model. *European Journal of Innovation Management*, *4*(2), 95–112.

Zheng, K. Z., Yim, C. K., & Tse, D. K. (2005). The Effects of Strategic Orientations on Technology- and Market-Based Innovations Breakthrough. *Journal of Marketing*, *69*(2), 42–60.

Zhou, J., Shin, S. J., Brass, D. J., Choi, J., & Zhang, Z. (2009). Social Networks, Personal Values, and Creativity: Evidence for Curvilinear and Interaction Effects. *Journal of Applied Psychology*, *94*(6), 1544–52.

Zhou, K. Z., & Wu, F. (2010). Technological Capability, Strategic Flexibility, and Product Innovation. *Academy of Management Journal*, *31*(5), 547–561.

Zhou, K. Z., Yim, C. K., & Tse, D. K. (2005). The Effects of Strategic Orientations on Technology- and Market-Based Breakthrough Innovations. *Journal of Marketing*, *69*, 42–80.

Zien, K. A., & Buckler, S. A. (1997). Dreams to Market: Crafting a Culture of Innovation. *Journal of Product Innovation Management*, *14*(4), 274–287.

Zollo, M., & Winter, S. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. *Organization Science*, *13*(3), 339–351.

9 Appendix

Appendix A01
Interview Guideline for Qualitative Interviews

German version

1. **Einleitung**
   1.1. Erläuterung der Interviewthematik und Ablauf des Interviews
   1.2. Anonymitätserläuterung
   1.3. Persönliche Vorstellung des Interviewpartners

2. **Innovationsmanagement**
   2.1. Welche Stärken hat der aktuelle Innovationsprozess?
   2.2. Welche Schwächen hat der aktuelle Innovationsprozess?
   2.3. Welche Strukturierungsansätze in der Frühphase der Innovation verwenden Sie?
      2.3.1. Inwiefern haben Sie schon vor der Einführung der Innovationsfelder mit diesen oder einer ähnlichen Strukturierungsform gearbeitet?
   2.4. Wie beobachten Sie frühe, unreife Technologien?
   2.5. Welche Rahmenbedingungen motivieren Sie und andere Kollegen am Innovationsprozess teilzuhaben?

3. **Innovationsfelder**
   3.1. Wie wurden Innovationsfelder in Ihrer Abteilung erarbeitet?
      3.1.1. Auf welche Schwierigkeiten sind Sie gestoßen?
      3.1.2. Wie war der Aufwand der Generierung?
   3.2. Wie nutzen Sie Innovationsfelder?
      3.2.1. Wie häufig nutzen Sie Innovationsfelder?
      3.2.2. Für welchen Zweck nutzen Sie diese?
      3.2.3. Wie empfinden Sie die Art der Umsetzung?

4. **Ideengenerierung**
   4.1. Wie generieren Sie Ideen?
   4.2. Können Sie dazu ein konkretes Beispiel nennen?
   4.3. Wenn Sie an Ideen in Ihrem Umfeld denken, wie radikal empfinden Sie diese?
   4.4. Wenn Sie an Ideen in Ihrem Umfeld denken, wie gut passen diese zur Strategie?
   4.5. Wenn Sie an Ideen in Ihrem Umfeld denken, wie gut sind diese am Markt orientiert?

5. **Kommunikation & Zusammenarbeit**
   5.1. Wie und wie oft kommunizieren Sie über Ideen abteilungsübergreifend? Wie oft in der Abteilung?
   5.2. Wie und wie oft kommunizieren Sie über Ideen bereichsübergreifend? Wie oft im Bereich?
   5.3. Wie und wie oft kommunizieren Sie über Ideen mit den Geschäftsbereichen?
   5.4. Wie wichtig ist der Austausch über Innovationsfelder?
   5.5. Wie häufig arbeiten Sie an übergreifenden Themen?
      5.5.1. Welche Rahmenbedingungen sind dafür wichtig?

6. **Strategie & Portfolio**
   6.1. Wie gut kennen Sie die Strategie des Unternehmens und der Forschung?
      6.1.1. Welche Möglichkeiten haben Sie, um mehr über die Strategie des Unternehmens herauszufinden?
      6.1.2. Können Sie mir eine Situation aus Ihrem Alltag nennen, bei der das Wissen um die Strategie für Sie wichtig gewesen ist?
      6.1.3. Wie wichtig ist es, dass Ideen zur Strategie passen?
   6.2. Wie gut sind Ihnen Themen aus anderen Bereichen bekannt?
      6.2.1. Wie gut fühlen Sie sich von anderen Bereichen über Themen informiert?
      6.2.2. Wie informieren Sie sich über die Themen der Forschung?

7. **Danksagung und Abschluss**

Appendix A01
Interview Guideline for Qualitative Interviews

English version

1. **Introduction**
    1.1. Introduction of interview topic and interview process
    1.2. Declaration of anonymity
    1.3. Introduction of interview partner

2. **Innovation management**
    2.1. What are the strengths of the current innovation process?
    2.2. What are the weaknesses of the current innovation process?
    2.3. What types of structure do you use for the management of the front-end of innovation?
        2.3.1. To what extent have you been working with innovation fields or a similar approach before they were implemented?
    2.4. How do you observe immature or advancing technologies?
    2.5. What are the contextual factors motivating you and your colleagues to participate in the innovation process?

3. **Innovation fields**
    3.1. How were innovation fields defined in your department?
        3.1.1. What were difficulties defining them?
        3.1.2. How much effort was involved?
    3.2. How do you use innovation fields?
        3.2.1. How often do you use innovation fields?
        3.2.2. For what purpose do you use innovation fields?
        3.2.3. What do you think about the way, innovation fields have been implemented?

4. **Idea generation**
    4.1. How do you generate ideas?
    4.2. Can you give me an example for idea generation in your department?
    4.3. When you think of ideas in your environment, how radical are they?
    4.4. When you think of ideas in your environment, how high is the fit to strategy?
    4.5. When you think of ideas in your environment, how market oriented are they??

5. **Communication and collaboration**
    5.1. How and how often do you communication about ideas across departments? How often within the department?
    5.2. How and how often do you communicate about ideas across areas? How often with the area?
    5.3. How and how often do you communicate about ideas with business divisions?
    5.4. How important is information exchange about innovation fields?
    5.5. How often do you work on overarching topics?
        5.5.1. What are crucial factors for this kind of collaboration?

6. **Strategy and portfolio**
    6.1. How well do you know the strategy of the company and the corporate R&D unit?
        6.1.1. Which possibilities do you have to discover more about the strategy of the company?
        6.1.2. Can you describe an everyday situation, where the knowledge about strategy was important?
        6.1.3. How important is it that ideas have a strategic fit?
    6.2. How well do you know topics from other research areas?
        6.2.1. How well do you feel informed about topics from other research areas?
        6.2.2. How do you keep informed about topic of the corporate R&D unit?

7. **Acknowledgement and conclusion**

Appendix A02
Overview of Qualitative Interviews Sorted by Research Units

No.	Unit	Interviewee	No. of employees	Intention to use and applications for innovation fields			Strategic orientation		Organizational context		External environment	
				General intention to use	Primary intended application	Secondary intended application	Customer orientation	Technology orientation	Centralization	Formalization	Market turbulence	Technology turbulence
3	Unit 1: Mobility Systems	IMA	74	low	None	Lifting synergies	high	low	high	low	high	high
15	Unit 1: Mobility Systems	IMA	85	low	None	Portfolio extension	high	low	high	high	low	low
20	Unit 1: Mobility Systems	IMA	87	low	None	-	high	low	high	high	low	low
19	Unit 2: Software Systems	Executive & IMA	69	high	Lifting synergies	Strategic purposes	low	high	high	high	low	high
9	Unit 2: Software Systems	Executive & IMA	82	high	Lifting synergies		high	low	low	low	low	high
17	Unit 2: Software Systems	Executive & IMA	59	high	Lifting synergies	Technology intelligence	low	high	low	high	high	high
21	Unit 3: Consumer Goods	Research employee	18	low	None	-	high	low	low	low	low	high
1	Unit 3: Consumer Goods	IMA	20	low	None	-	high	low	high	high	low	high
22	Unit 3: Consumer Goods	Executive	41	low	None	-	high	low	high	high	high	high
7	Unit 4: Materials & Sensors	IMA	69	high	Strategic purposes		high	low	low	high	low	high
6	Unit 4: Materials & Sensors	Executive & IMA	24	high	Technology intelligence	Strategic purposes	high	low	low	high	low	low
16	Unit 4: Materials & Sensors	IMA	51	low	None	Lifting synergies	low	high	low	high	high	high
5	Unit 4: Materials & Sensors	IMA	82	low	None	Ideation	high	low	high	high	high	high
12	Unit 4: Materials & Sensors	IMA	81	low	None	Lifting synergies	high	low	high	high	high	high
4	Unit 5: Components	IMA	72	high	Strategic purposes	Ideation	low	high	high	high	low	low
8	Unit 5: Components	IMA	45	high	Strategic purposes		low	high	low	high	low	high
18	Unit 5: Components	IMA	47	high	Lifting synergies	Ideation	low	high	high	high	low	high
2	Unit 5: Components	IMA	34	low	None	Strategic purposes	low	high	high	low	low	low
14	Unit 6: Manufacturing Technologies	Executive & IMA	83	high	Strategic purposes	Portfolio extension	high	low	high	high	low	high
11	Unit 6: Manufacturing Technologies	IMA	101	high	Technology intelligence	Strategic purposes	high	low	low	low	low	low
13	Unit 6: Manufacturing Technologies	IMA	42	high	Technology intelligence	Strategic purposes	high	low	low	high	low	high
10	Unit 6: Manufacturing Technologies	IMA	65	low	None	Strategic purposes	high	low	high	low	low	high

No disclosure for reasons of confidentiality.

Transcripts available upon request.

No disclosure for reasons of confidentiality.

Data table available upon request.

No disclosure for reasons of confidentiality.

Questionnaire available upon request.

Appendix A06
Overview of Translated Questionnaire Items

Dependent Variables

	Construct	English items	German translation	Source of scale
General Intention	**Intention to use**	I can imagine using innovation fields in the future. [intent1]	Ich kann mir vorstellen, Innovationsfelder zukünftig zu nutzen.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		In the future, I intend using innovation fields. [intent2]	Zukünftig habe ich vor, Innovationsfelder zu nutzen.	
Types of applications for innovation fields	**Application of innovation fields for strategic purposes**	Using innovation fields can strengthen the concentration and focus to dedicated topics [use_strat1]	Innovationsfelder zu nutzen, kann die Konzentration und den Fokus auf bestimmte Themen stärken.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		Using innovation fields can support the strategic orientation of our department. [use_strat2]	Innovationsfelder zu nutzen, kann die strategische Orientierung unserer Abteilung unterstützen.	
		Innovation fields improve the overview of topics. [use_strat3]	Innovationsfelder verbessern den Überblick über Themen.	
		Innovation fields can help to discover strategic gaps [use_strat4]	Innovationsfelder können helfen, strategische Lücken aufzudecken.	
	Application of innovation fields for early technology detection	Using innovation fields can support me in early technology detection. [use_tec1]	Innovationsfelder zu nutzen, kann mich bei der Technologiefrüherkennung unterstützen.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		Innovation fields can help me to assign weak signals. [use_tec2]	Innovationsfelder können mir helfen, schwache Signale zuzuordnen.	
		Innovation fields improve the discovery of trends. [use_tec3]	Innovationsfelder verbessern die Entdeckung von Trends	
	Application of innovation fields for ideation	Using innovation fields can support me in ideation. [use_idea1]	Innovationsfelder zu nutzen, kann mich bei der Ideenfindung unterstützen.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		Innovation fields are good guiding rails for ideation. [use_idea2]	Innovationsfelder sind gute Leitplanken für die Ideenfindung.	
		Innovation fields are suitable as topics for innovation workshops. [use_idea3]	Innovationsfelder sind als Themen gut geeignet für Innovationsworkshops.	
	Application of innovation fields for portfolio extension	Using innovation fields can help to develop a new business field. [use_div1]	Innovationsfelder zu nutzen kann helfen, neue Geschäftsfelder zu erschließen.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		Using innovation fields can facilitate finding radical innovations. [use_div2]	Innovationsfelder zu nutzen, kann das Finden von radikalen Innovationen erleichtern.	
		~~Innovation fields can be an instrument to execute studies and projects that lie adjacent to the competencies of the department. [use_div3]~~	~~Innovationsfelder können ein Mittel sein, Studien und Projekte durchzuführen, die außerhalb der Kompetenz der Abteilung liegen~~	
	Application of innovation fields for lifting synergies	Innovation fields can help me bring transparency over current and future research topics. [use_syn1]	Innovationsfelder können mir helfen, die Transparenz über aktuelle und zukünftige Forschungsthemen zu erleichtern.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		Innovation fields can help me discover similar topics.[use_syn2]	Innovationsfelder können mir bei der Entdeckung von ähnlichen Themen behilflich sein.	
		Innovation fields increase the probability to lift synergies between topics. [use_syn3]	Innovationsfeldern erhöhen die Wahrscheinlichkeit, Synergien zwischen Themen aufzudecken	

Dependent Variables

	Construct	English items	German translation	Source of scale
Proficiency-related variables	**Innovation fields enhancing performance**	Using innovation fields can increase the performance of the research unit. [use_per1]	Innovationsfelder zu nutzen, kann die Leistungsfähigkeit der Forschung stärken.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		With innovation fields, we can be more effective in the future. [use_per3]	Mit Innovationsfeldern können wir zukünftig als Forschung leistungsfähiger sein	
		Using innovation fields can increase the success of the research unit. [use_per2]	Innovationsfelder zu nutzen, kann den Erfolg der Forschung erhöhen.	
	Innovation fields enhancing innovativeness	Using innovation fields has no influence on the innovativeness of the research unit. [use_inno1] (reverse coded)	Innovationsfelder zu nutzen, hat keinen Einfluss auf die Innovativität der Forschung.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		As research unit, with innovation fields we are more innovative in the future. [use_inno2]	Mit Innovationsfeldern sind wir in Zukunft als Forschung innovativer sein.	
		Using innovation fields can contribute to the innovativeness of the research unit. [use_inno3]	Innovationsfelder zu nutzen, kann einen Beitrag zur Innovatitivät der Forschung leisten.	
	Perceived Usefulness	With regards to the development of new products and services, innovation fields can contribute to the performance, thus the success of the research unit. [perc_use1]	In Bezug auf die Entwicklung neuer Produkte und Dienstleistungen können Innovationen einen Beitrag leisten, um die Leistungsfähigkeit zu steigern, also den Erfolg der Forschung zu erhöhen.	Wangpipatwong, Chutimaskul & Paparatorn, 2008 / Escobar-Rodríguez, Monge-Lozano & Romero-Alonso, 2012 [Adaption of TAM construct intention to use from Venkatesh & Davis, 2000]
		With regards to the development of new products and services, innovation fields can contribute to the productivity, thus the speed of developing ideas and concepts. [perc_use2]	In Bezug auf die Entwicklung neuer Produkte und Dienstleistungen können Innovationen einen Beitrag leisten, um die Produktivität zu steigern, also Ideen und Konzepte schneller zu entwickeln.	
		With regards to the development of new products and services, innovation fields can contribute to the effectiveness, thus the choice of the right topics. [perc_use3]	In Bezug auf die Entwicklung neuer Produkte und Dienstleistungen können Innovationen einen Beitrag leisten, um die Effektivität zu steigern, also die richtigen Themen auszuwählen.	

Appendix A06
Overview of Translated Questionnaire Items

Independent variables

	Construct	English items	German translation	Source of scale
External environment	**Technology turbulence**	The technologies in our industry are changing rapidly. [turb_tec1]	Die Technologien in der Industrie unserer Geschäftsbereiche, für die wir arbeiten, verändern sich sehr schnell.	Jaworski & Kohli, 1993
		Technological changes provide big opportunities in our industry. [turb_tec2]	Technologische Veränderungen bieten uns große Chancen in der Industrie unserer Geschäftsbereiche, für die wir arbeiten.	
		A large number of new product ideas have been made possible through technical breakthroughs in our industry. [turb_tec3]	Eine große Anzahl von neuen Produktideen sind erst durch technologische Durchbrüche in der Industrie unserer Geschäftsbereiche, für die wir arbeiten, möglich gemacht worden.	
		Major technological changes in our industry are rather scarce. [turb_tec4] (reverse coded)	Große technologische Veränderungen sind in der Industrie unserer Geschäftsbereiche, für die wir arbeiten, eher selten.	
	Market turbulence	In our business, customers' product preferences change quite a bit over time. [turb_mark1]	In unserem Geschäft verändern sich die Produktwünsche der Kunden / Geschäftsbereiche recht schnell über die Zeit.	Jaworski & Kohli, 1993
		Our customers tend to look for new products all the time. [turb_mark2]	Unsere Kunden / Geschäftsbereiche schauen sich ständig nach neuen Produkten / Technologien um.	
		We are witnessing demand for our products and services from customers who never bought them before. [turb_mark3]	Wir beobachten eine wachsende Nachfrage von Produktentwicklungen und Dienstleistungen durch unsere Kunden / Geschäftsbereiche, die diese vorher noch nie angefragt haben.	
		New customers tend to have product-related needs that are different from those of our existing customers. [turb_mark4]	Neue Kunden / Geschäftsbereiche haben andere produktbezogene Bedürfnisse als bestehende (bisherige) Geschäftsbereiche / Kunden.	
	Competitiveness	Competition in our industry is cutthroat. [comp1]	Wettbewerb ist in der Industrie / Branche, für die unsere Abteilung arbeitet, sehr stark.	Jaworski & Kohli, 1993
		~~Anything that one competitor can offer, others can match readily. [comp3]~~	~~Was ein Wettbewerber der Industrie / Branche, für die unsere Abteilung arbeitet, auf den Markt bringt, kann von anderen schnell nachgeahmt werden.~~	
		Price competition is a hallmark of our industry. [comp4]	Preisdruck ist ein Merkmal der Industrie / Branche, für die unsere Abteilung tätig ist.	
		Our competitors are relatively weak. [comp6] (reverse coded)	Die Wettbewerber der Industrie / Branche, für die unsere Abteilung arbeitet, sind verhältnismäßig schwach.	

Independent variables

	Construct	English items	German translation	Source of scale
Strategic orientation	**Customer orientation**	Our business objectives are driven primarily by customer satisfaction. [strat_cust1]	Unsere Ziele sind vor allem von der Zufriedenheit der Geschäftsbereiche geprägt.	Gatignon & Xuereb, 1997 / Narver & Slater, 1990 / Markham, 2013
		We constantly monitor our level of commitment and orientation to serving customer needs. [strat_cust2]	Wir orientieren uns ständig an den Kundenbedürfnissen / Bedürfnissen des Geschäftsbereichs.	
	Technology orientation	Our departmen uses sophisticated technologies in Its new product development. [strat_tec1]	Unsere Abteilung nutzt neuartige Technologien in der Produktentwicklung.	Gatignon & Xuereb, 1997 / Narver & Slater, 1990 / Markham, 2013
		The products that we develop are always at the state of the art of the technology. [stract_tec2]	Die Produkte, die wir entwickeln, sind technologisch immer auf dem neuesten Stand der Technik.	
	Exploitation	We frequently refine the provision of existing products and services. [exploit1]	Unsere Innovationsaktivitäten drehen sich häufig um bereits existierende Produkte und Dienstleistungen.	Jansen & Van den Bosch, 2006
		We regularly implement small adaptations to existing products and services. [exploit2]	Wir führen oft kleine Änderungen an bestehenden Produkten und Dienstleistungen ein.	
		We introduce improved, but existing products and services for our local market. [exploit3]	Der Kunde / Geschäftsbereich für den wir arbeiten, bringt verbesserte, aber bestehende Produkte und Dienstleistungen auf den Markt.	
		We improve our provision's efficiency of products and services. [exploit4]	Wir verbessern die Effizienz unserer Produkte und Dienstleistungen.	
		~~Lowering costs of internal processes is an important objective. [exploit7]~~	~~Die Kosten von internen Prozessen zu verkleinern, ist ein wichtiges Ziel.~~	
	Exploration	Our department accepts demands that go beyond existing products and services. [explore1]	Unsere Abteilung kümmert sich auch um Anforderungen, die über unsere bisherigen Kompetenzen hinausgehen.	Jansen & Van den Bosch, 2006
		We invent new products and services. [explore2]	Wir erfinden neue Produkte und Dienstleistungen.	
		We experiment with new products and services in our local market. [explore3]	Wir experimentieren mit neuen Produkten und Dienstleistungen für unsere Geschäftsbereiche.	
		We commercialize products and services that are completely new to our unit. [explore4]	Die Kunden / Geschäftsbereiche, für die wir arbeiten, bringen Produkte und Dienstleistungen auf den Markt, die völlig neu sind für den Geschäftsbereich.	

Appendix A06
Overview of Translated Questionnaire Items

Independent Variables

	Construct	English items	German translation	Source of scale
Organizational context	**Formalization**	I feel that I am my own boss in most matters. [form1] (reverse coded)	Ich habe den Eindruck, dass ich in den meisten Fällen großen Handlungsspielraum bei der Gestaltung meiner Arbeit habe.	Jansen & Van den Bosch, 2006 / Jaworski & Kohli, 1993
		How things are done around here is left up to the person doing the work. [form3] (reverse coded)	Wie die Dinge in unserer Abteilung angegangen werden, ist der Person überlassen, die die Arbeit macht.	
		~~Rules and procedures occupy a central place in the organizational department. [form6]~~	~~Die genaue Einhaltung der Prozesse hat einen hohen Stellenwert in unserer Abteilung.~~	
		~~Whatever situation arises, written procedures are available for dealing with it. [form10]~~	~~Egal in welcher Situation ich mich befinde, es gibt immer einen existierenden Prozess dazu.~~	
	Centralization	A person who wants to make his own decision would be quickly discouraged here. [cent1]	Eine Person, die ihre eigenen Entscheidungen treffen möchte, wäre hier schnell demotiviert.	Jaworski & Kohli, 1993
		Even small matters have to be referred to someone higher up for a final answer. [cent2]	Auch kleine Dinge müssen mit jemandem über mir für eine endgültige Entscheidung abgesprochen werden.	
		I have to ask my boss before I do almost anything. [cent3]	Ich muss meinen Vorgesetzten fast immer fragen, bevor ich etwas machen darf.	
		Any decision I make has to have my boss' approval. [cent4]	Fast jede Entscheidung, die ich treffe, muss von meinem Vorgesetzten abgesegnet sein.	
	Interdepartmental connectedness	In this research sector, it is easy to talk with virtually anyone you need to, regardless of rank or position. [connect1]	In der Forschung ist es einfach mit fast jedem zu sprechen, unabhängig von Rang oder Position.	Jaworski & Kohli, 1993
		There is ample opportunity for informal "hall talk" among individuals from different departments in this business sector. [connect2]	Es gibt viele Möglichkeiten für informelle Flurgespräche zwischen Einzelnen von verschiedenen Abteilungen in der Forschung.	
		In this business sector, employees from different departments feel comfortable calling each other when the need arises. [connect3]	In der Forschung haben Mitarbeiter von verschiedenen Abteilungen kein Problem damit, andere anzurufen, wenn sie Expertise oder Rat benötigen.	
		People around here are quite accessible to those in other units. [connect4]	Kollegen in der Forschung sind im Allgemeinen ziemlich gut erreichbar für andere Kollegen.	
	Opportunity screening	We have interdepartmental meetings at least once a quarter to discuss market trends and developments. [opp_screen1]	Wir haben mindestens einmal im Quartal abteilungsübergreifende Meetings, um Trends und Entwicklungen zu diskutieren.	Kohn & Hüsig, 2005 / Jaworski & Kohli,1993
		Marketing personnel in our department spends time discussing customers' future needs with other functional departments. (original) // In our department, we spend time discussing future technological possibilities and requirements with other business divisions. [opp_screen2]	In unserer Abteilung verbringen wir Zeit, um zukünftige technologische Möglichkeiten und Anforderungen mit Geschäftsbereichen zu diskutieren.	
		Our department periodically circulates documents (e.g., reports, newsletters) that provide information on our customers. [opp_screen3]	In unserer Abteilungen gehen regelmäßig Dokumente herum, die uns mit Informationen über die Industrie / Branche, für die wir arbeiten, versorgen.	
		When something important happens to a major customer or market, the whole business department knows about it in a short period. [opp_screen4]	Wenn einem großen Endkunden oder Markt der Industrie / Branche, für die wir tätig sind, etwas wichtiges passiert, weiß in unserer Abteilung jeder sehr schnell darüber Bescheid.	

Independent Variables

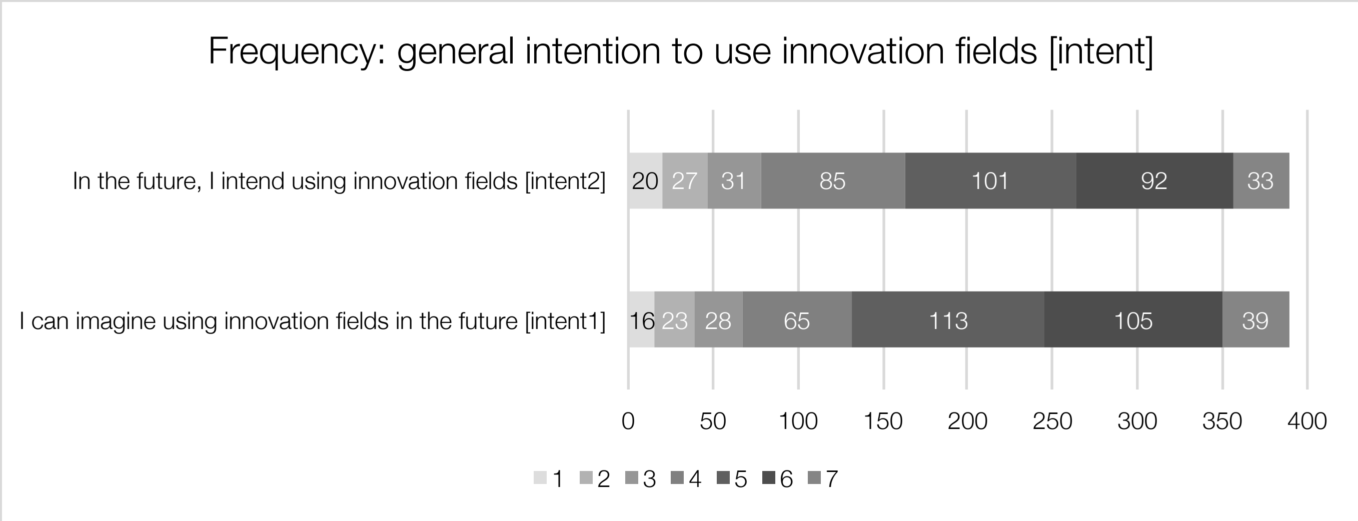
	Construct	English items	German translation	Source of scale
Control variables	**Process satisfaction**	Our activities preceding the start of development are well organised.[sat_pro1]	Unsere Innovationsaktivitäten vor SOD sind gut organisiert.	Kohn & Hüsig, 2005
		I am satisfied with the results of our activities preceding the start of development. [sat_pro2]	Ich bin zufrieden mit den Ergebnissen unserer Innovationsaktivitäten vor SOD.	
	Unit factor	unit [1-6] [Mobility Systems, Software Systems, Consumer Goods & Building Technology, Materials & Sensors, Components & Simulation, Manufacturing Technologies]	Bereich [1-6] [Mobilitätssysteme, Software Systeme, Konsumgüter & Gebäudetechnik, Materialien & Sensoren, Komponenten & Simulation, Fertigungstechnik]	-
	Age	Age [free numerical field]	Alter [freies Textfeld]	-
	Work tenure	How long have you been working for the company? [free numerical field]	Wie lange arbeiten Sie schon im Unternehmen? [freies Textfeld]	-
	Managerial responsibility	Do you possess managerial responsibility? [yes, no]	Haben Sie Personalverantwortung? [ja, nein]	-

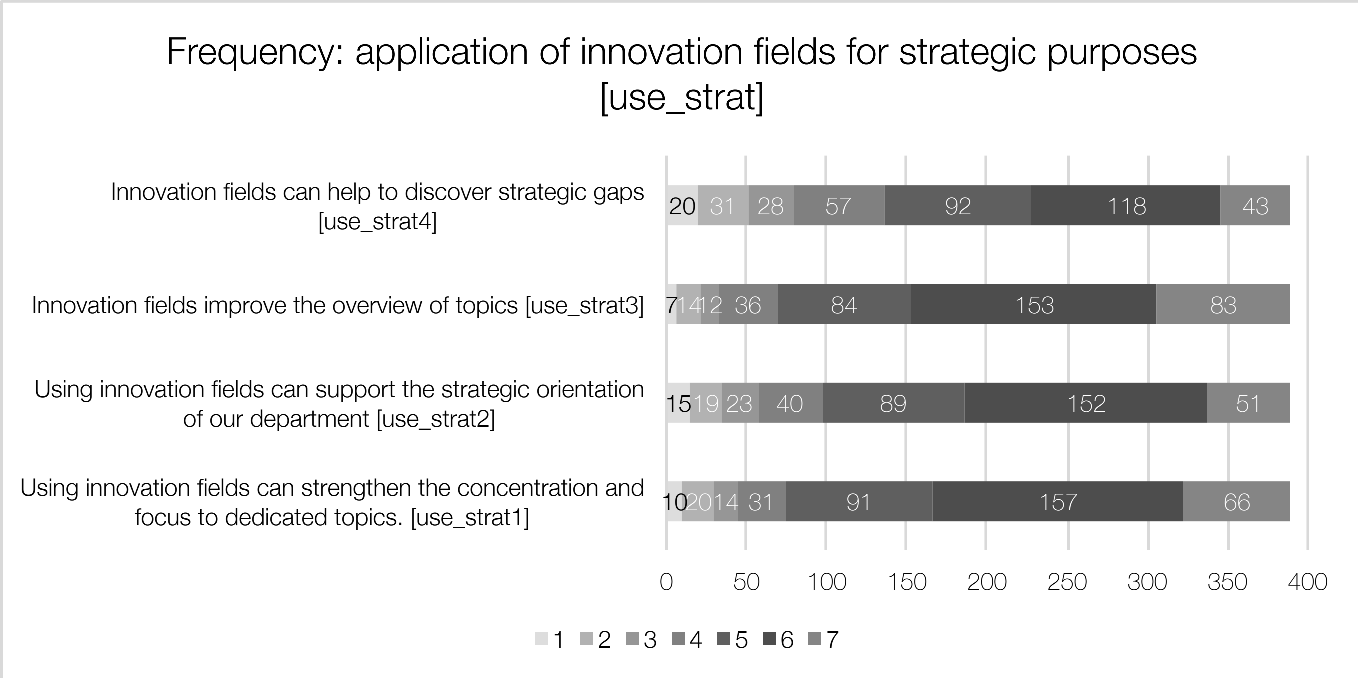
Independent Variables

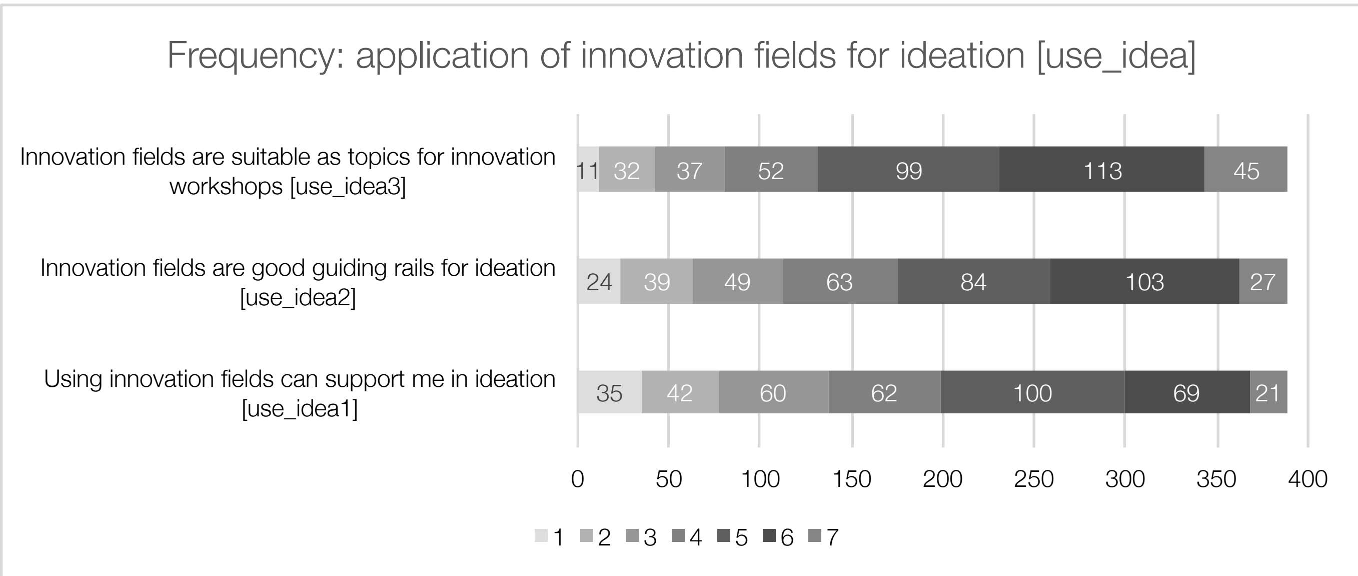
	Construct	English items	German translation	Source of scale
Descriptives	**Portfolio satisfaction**	I am satisfied with our current activity- / topic portfolio preceding the start of development. [sat_por1]	Ich bin total zufrieden mit unserem aktuellen Aktivitäten- / Themen-Portfolio vor SOD.	Kohn & Hüsig, 2005
	Usage of internal database	How often do you use internal database? [data1] [never, once a year, once every six months, once a quarter, once a month, once a week, daily]	Wie oft nutzen Sie die interne online Datenbank für Innovation? nie, mindestens einmal im Jahr, mindestens einmal alle sechs Monate, mindestens einmal pro Quartal, mindestens einmal im Monat, mindestens einmal pro Woche, täglich]	-
		How often do you use the innovation field module in internal database? [data2] [never, once a year, once every six months, once a quarter, once a month, once a week, daily]	Wie oft nutzen Sie das Innovationsfeldmodul in der internen online Datenbank? [nie, mindestens einmal im Jahr, mindestens einmal alle sechs Monate, mindestens einmal pro Quartal, mindestens einmal im Monat, mindestens einmal pro Woche, täglich]	-
	Usage of innovation fields	What would you use innovation fields for? [portfolio extension, lifting synergies, strategic purposes, early technology detection, ideation]	Für was würden Sie Innovationsfelder am ehesten nutzen? [Portfolioerweiterung, Entdeckung von ähnlichen Themen, strategische Orientierung, Technologiefrüherkennung, Leitplanken für die Ideenfindung]	-

Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution dependent variables

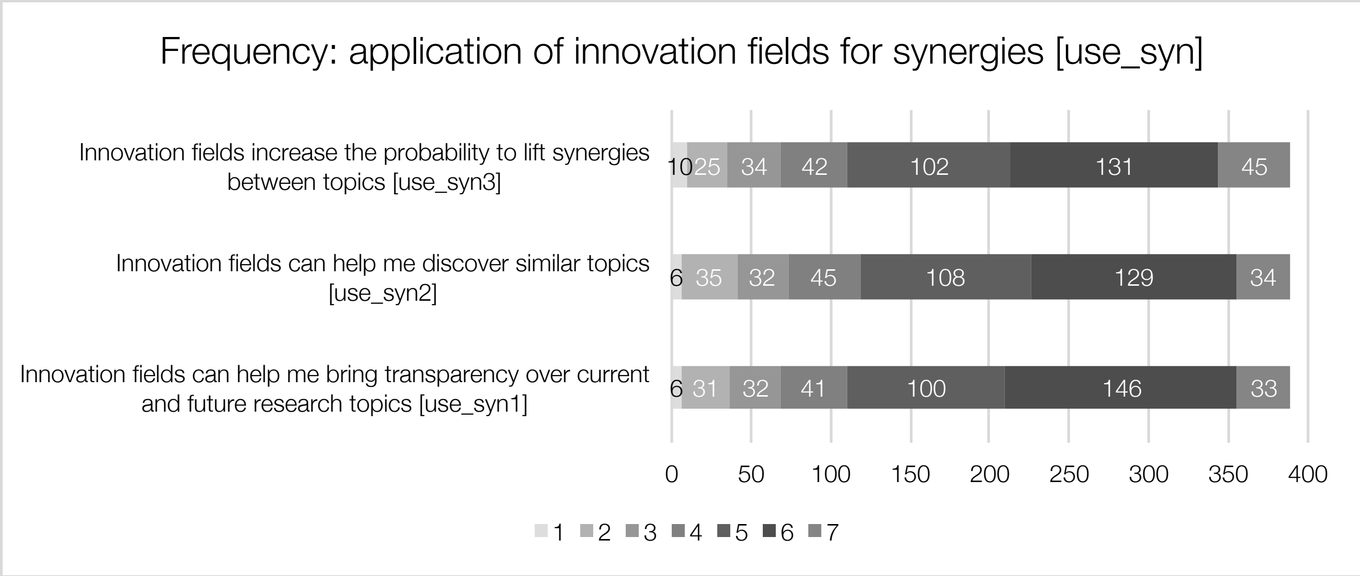


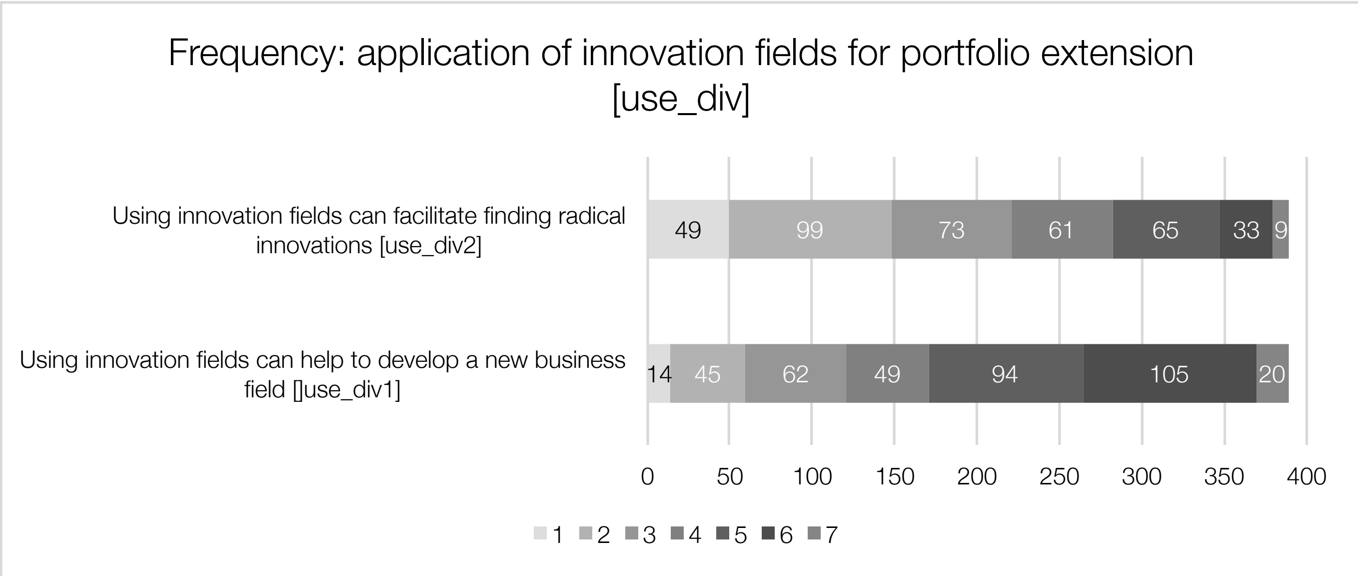


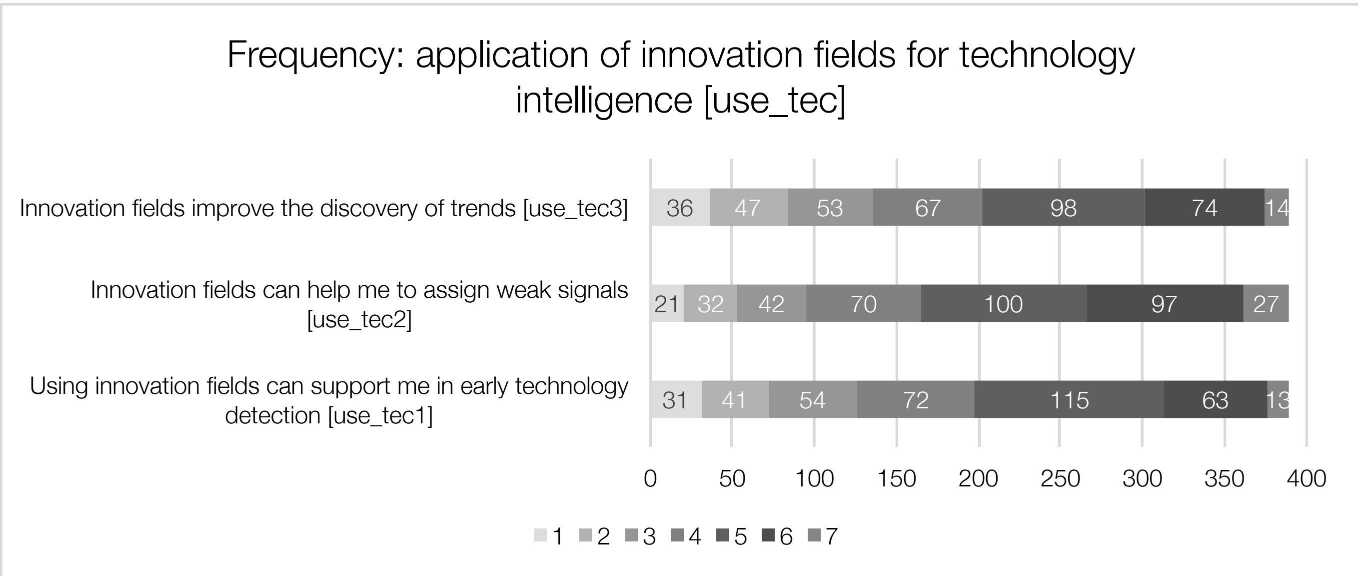


Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution dependent variables

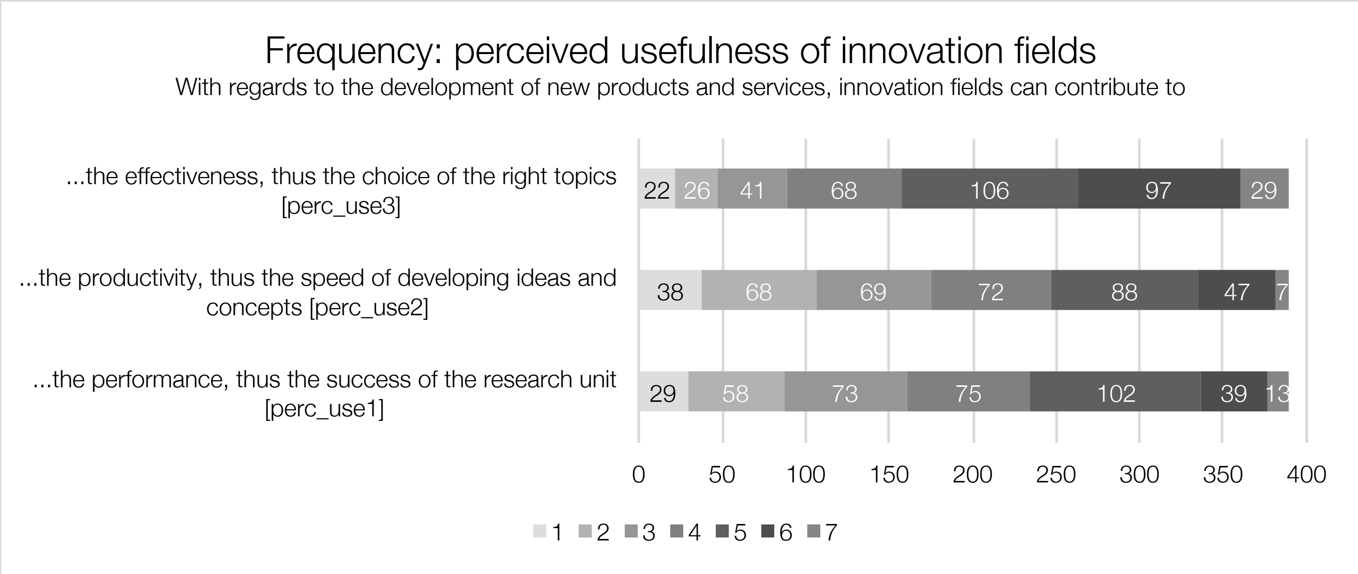


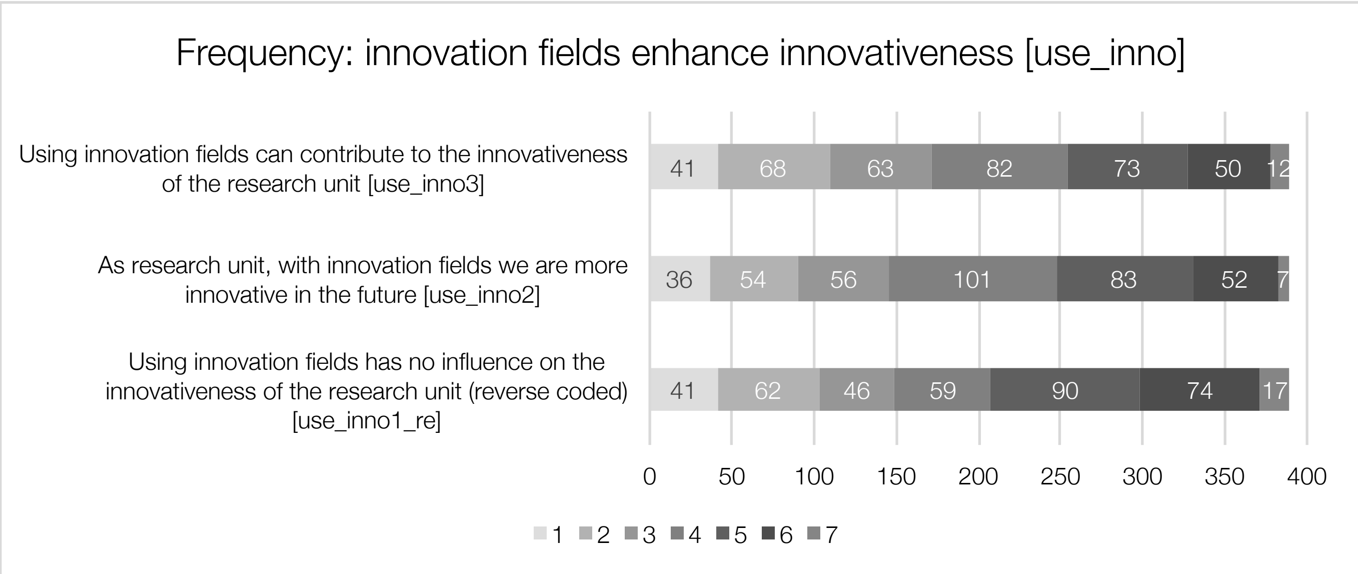


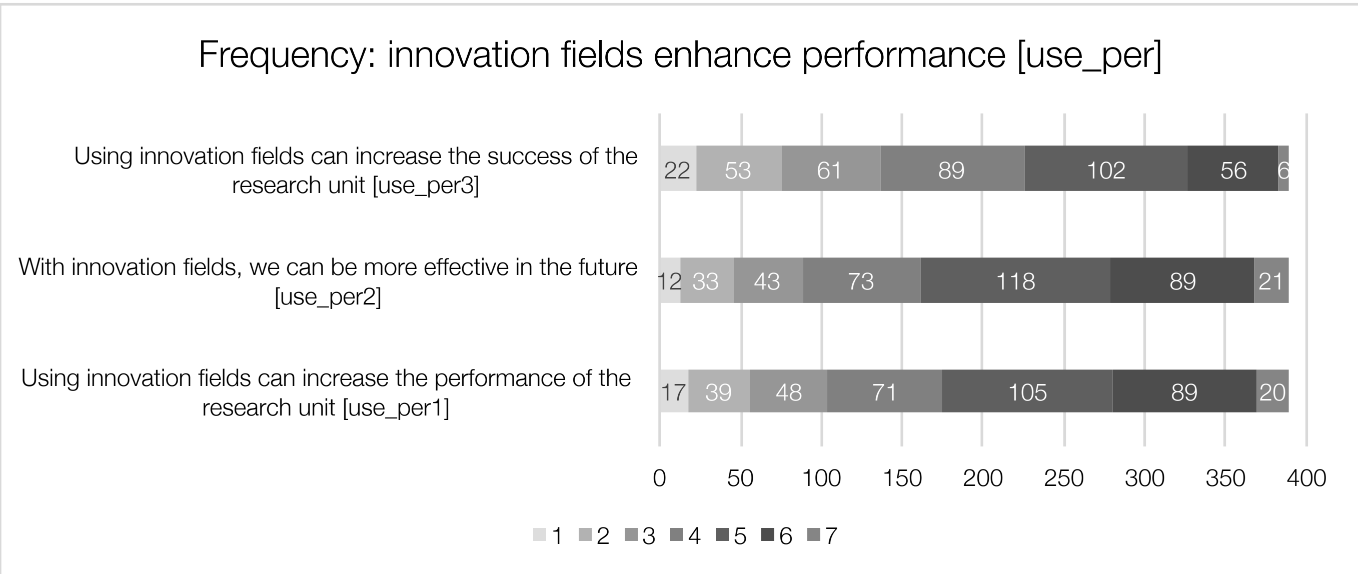


Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution dependent variables

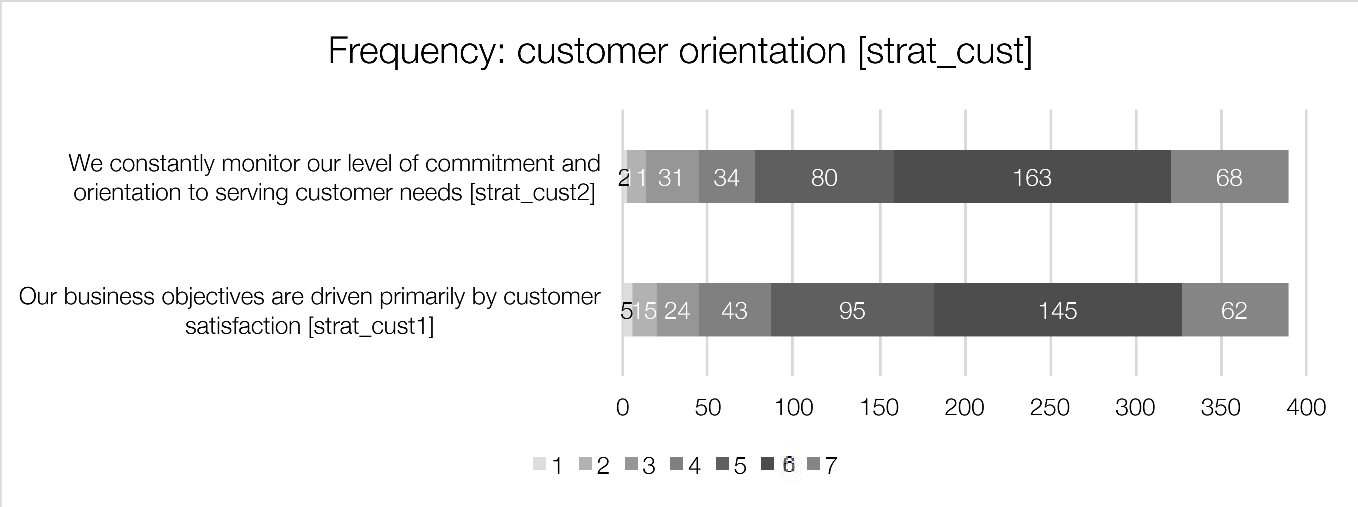


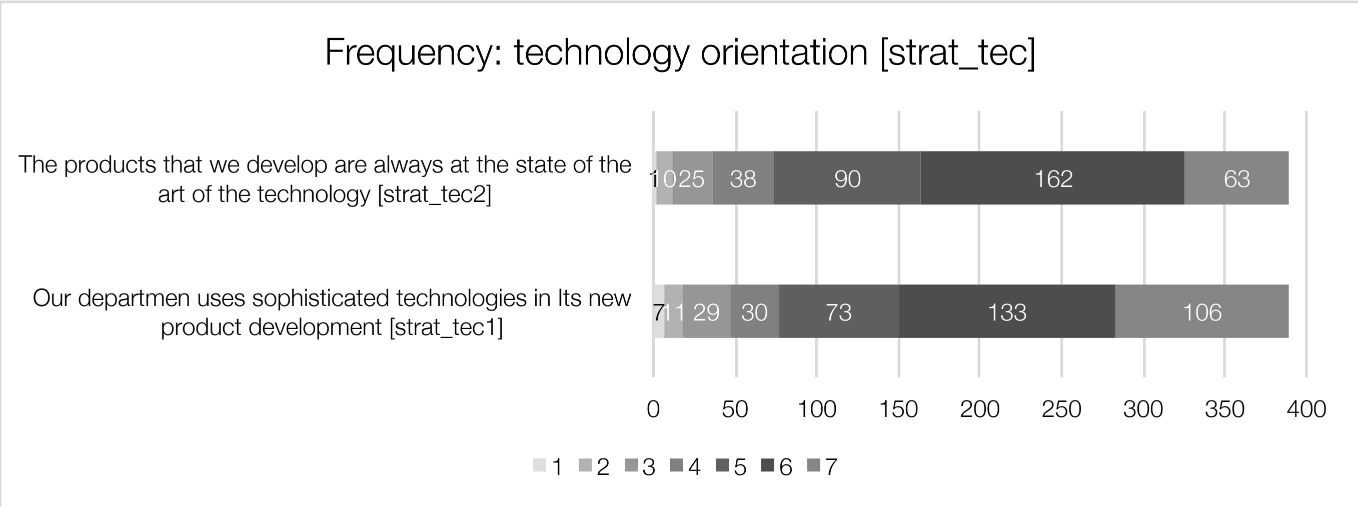


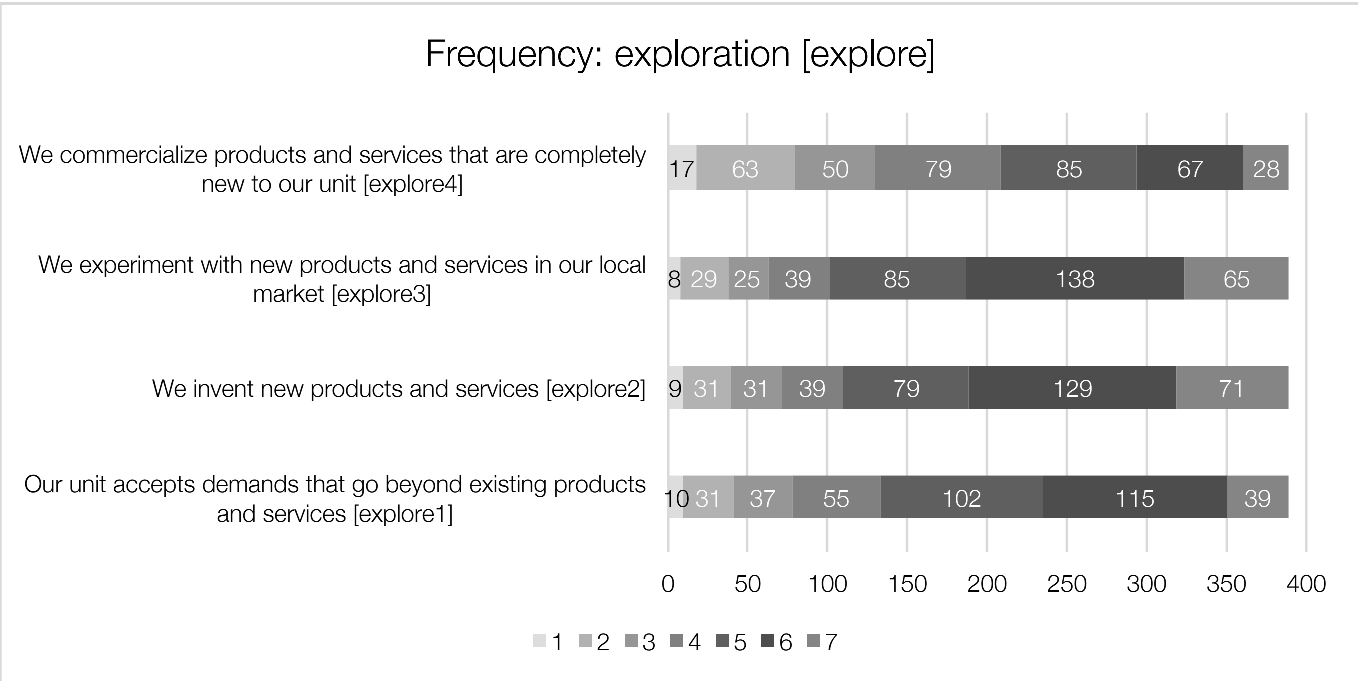


Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution independent variables: strategic orientation

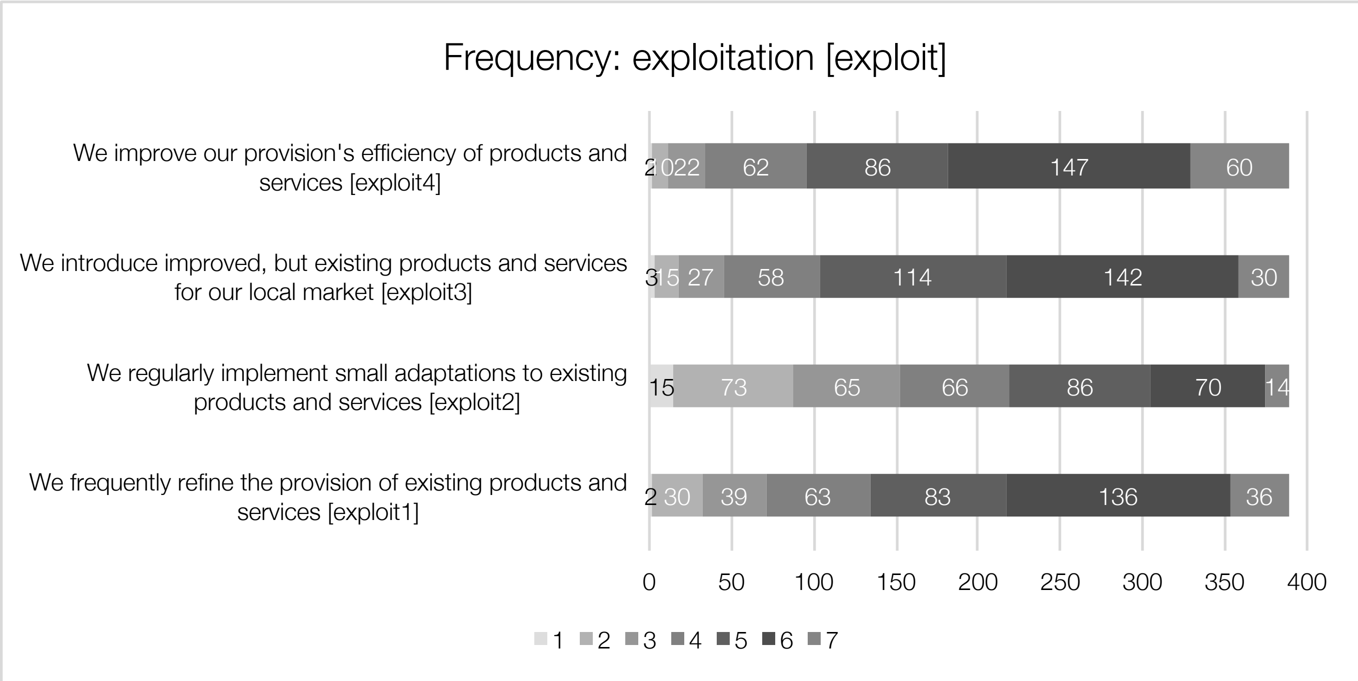




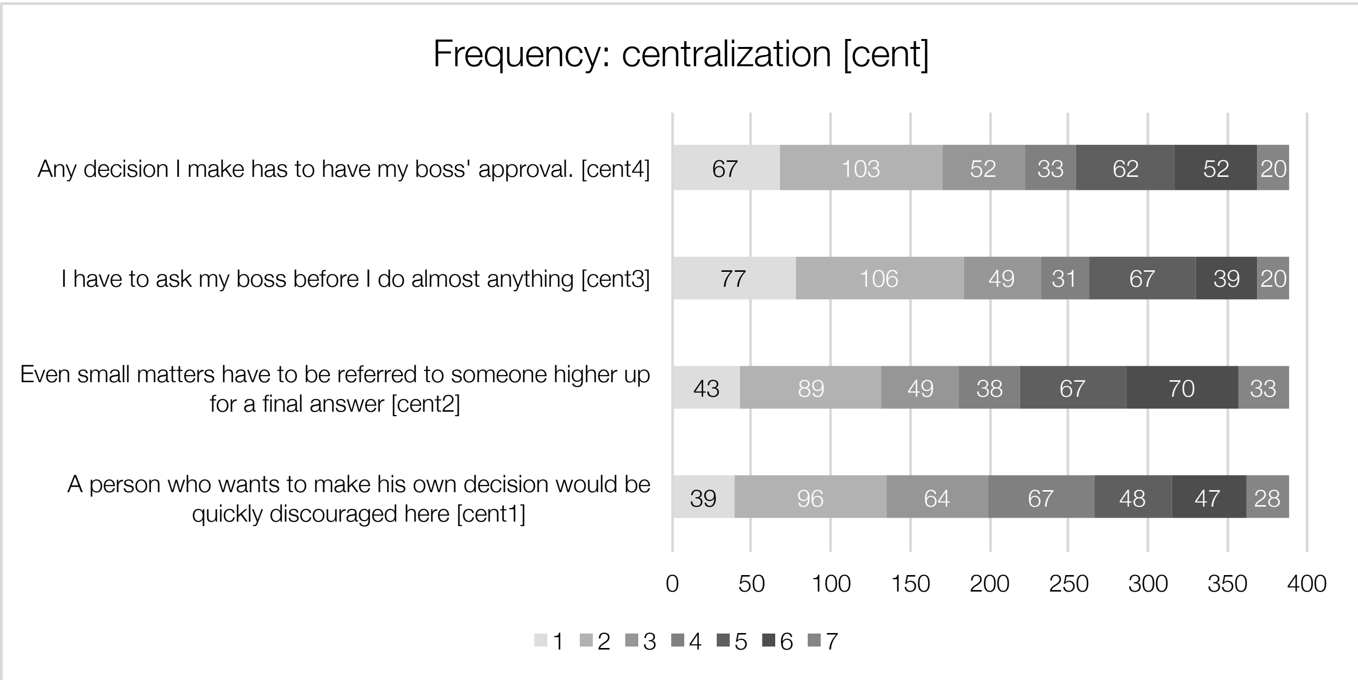


Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution independent variables: strategic orientation

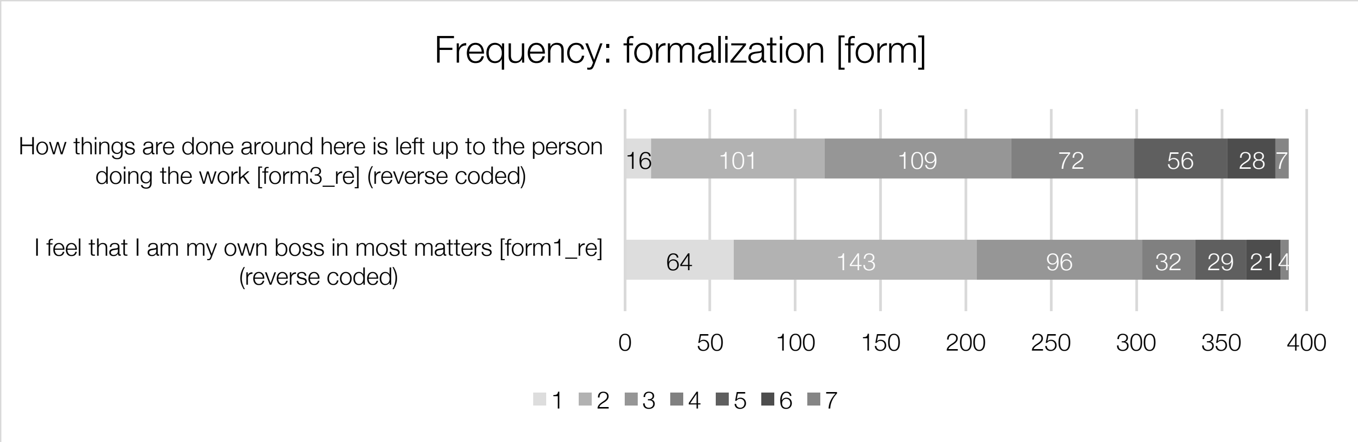


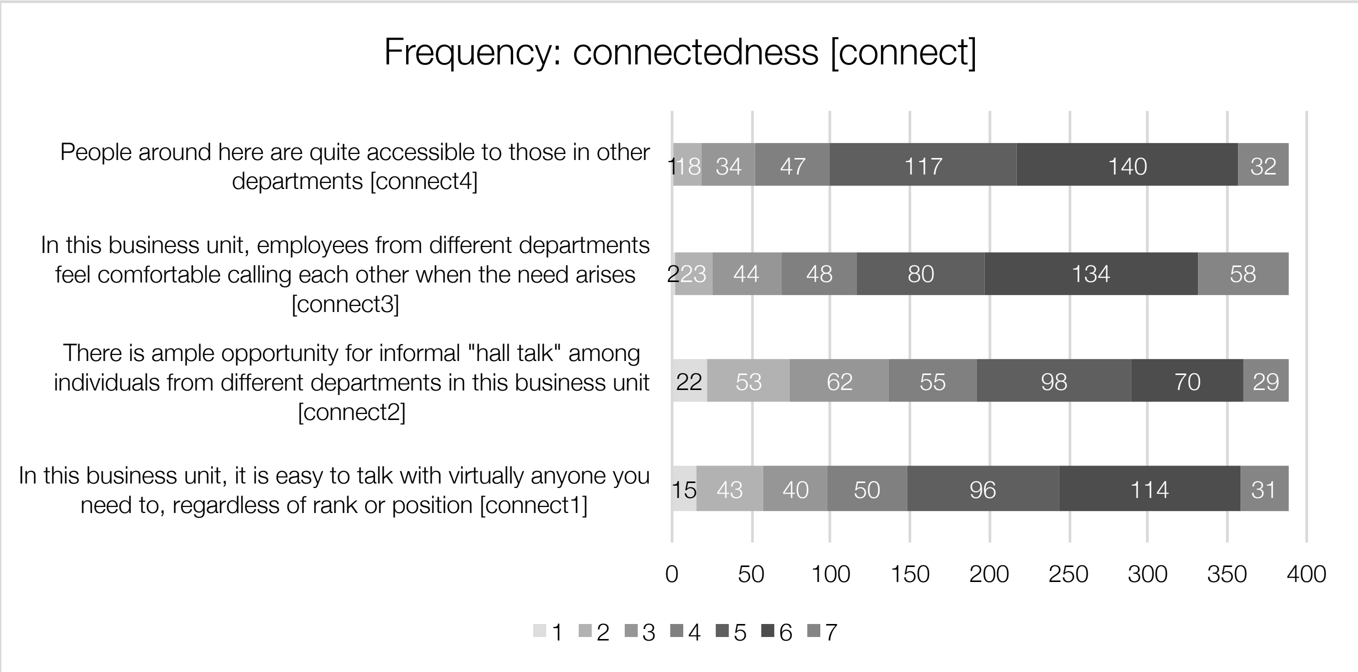
Frequency distribution independent variables: organizational context

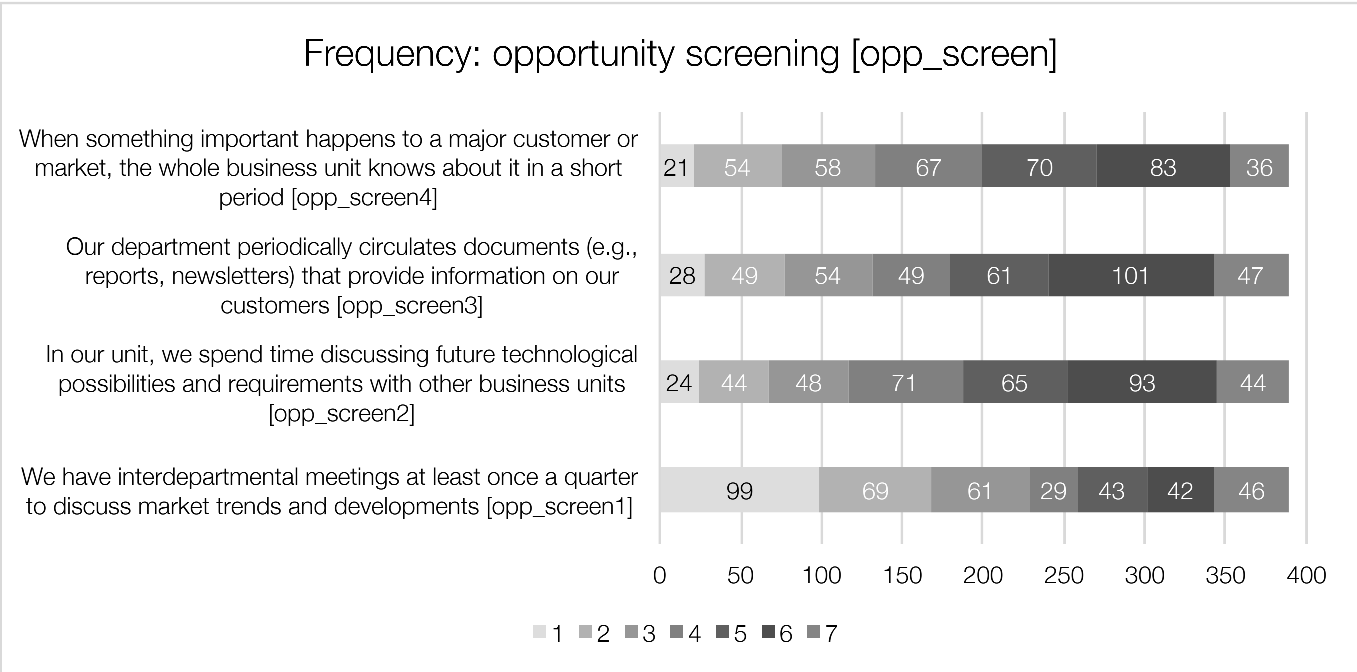


Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution independent variables: organizational context

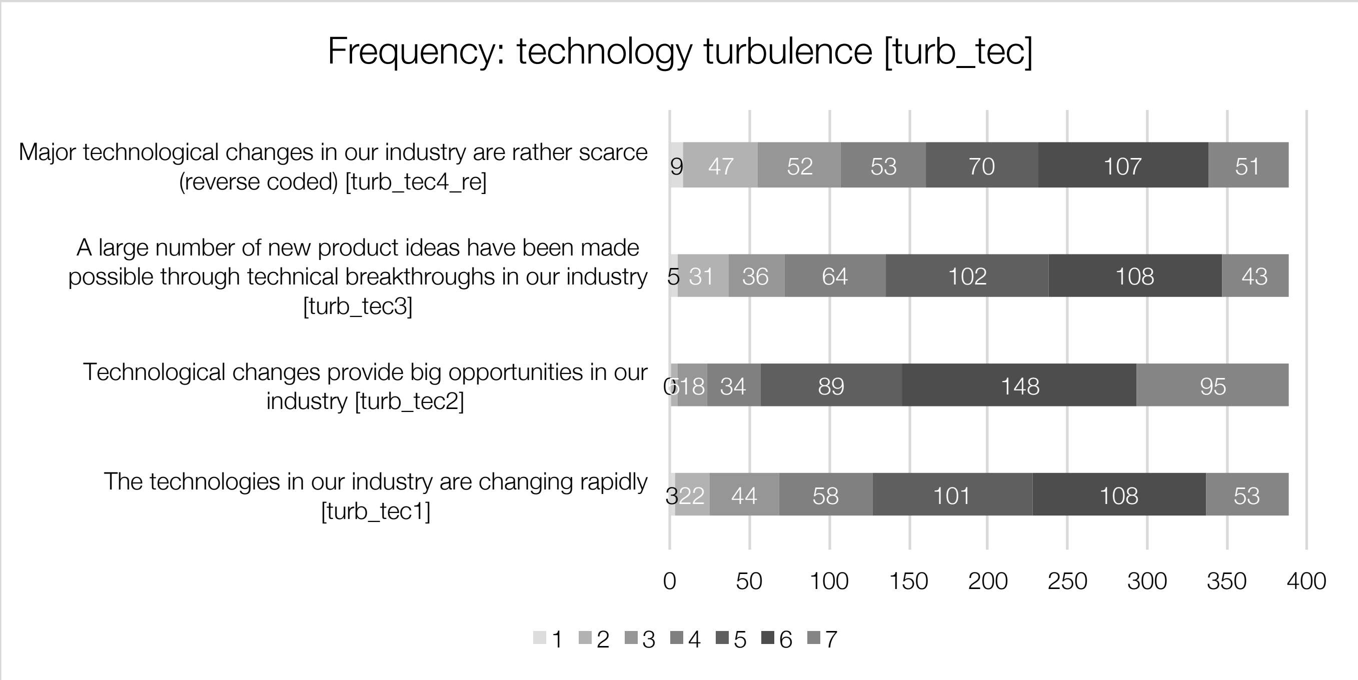


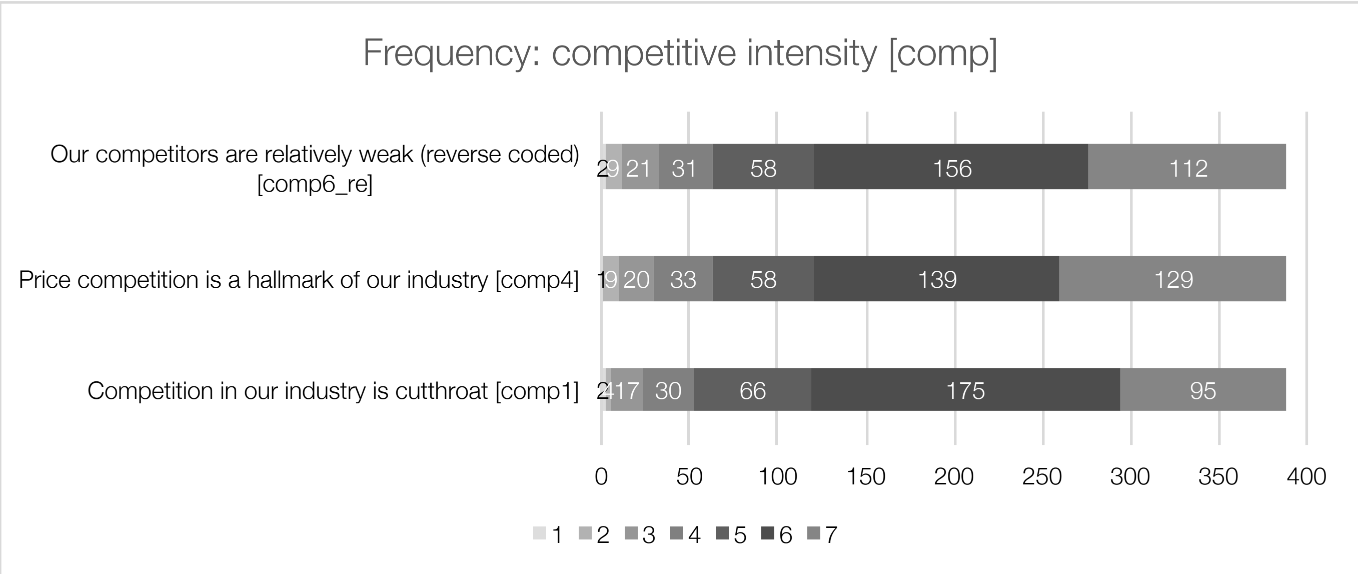




Appendix A07
Frequency Distribution of Imputed Questionnaire Items

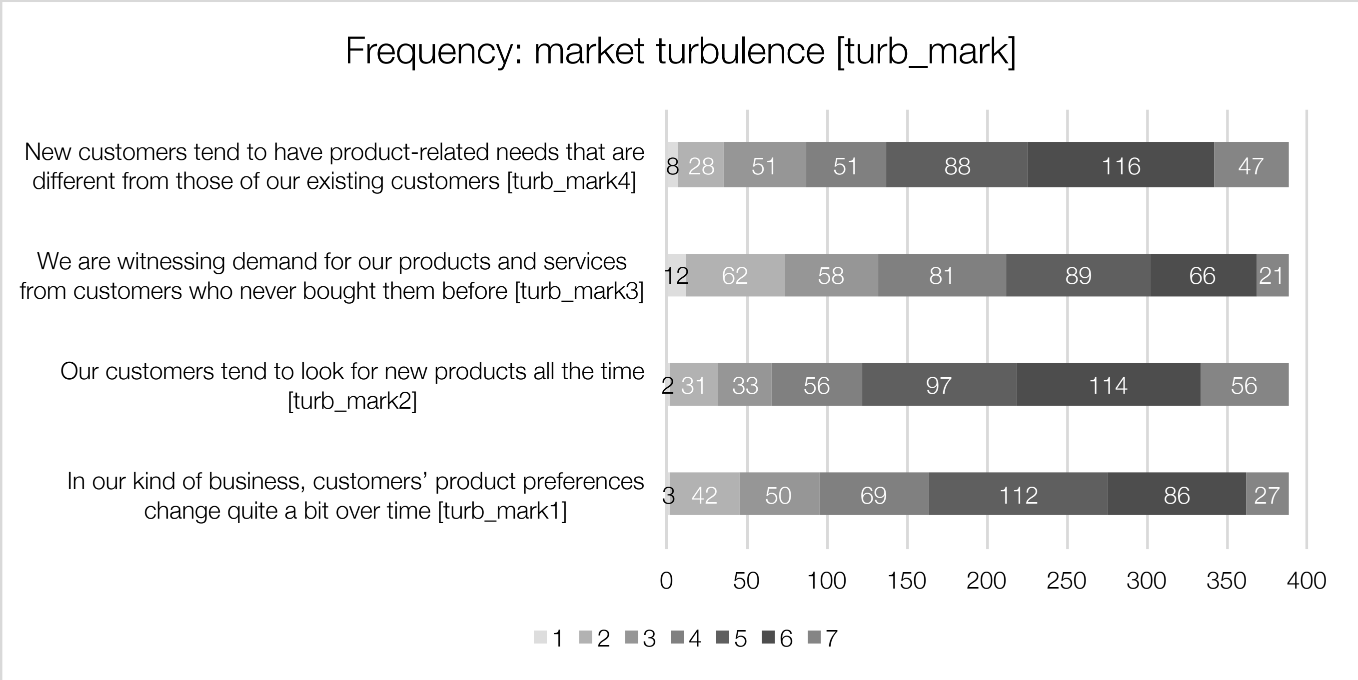
Frequency distribution independent variables: external environment



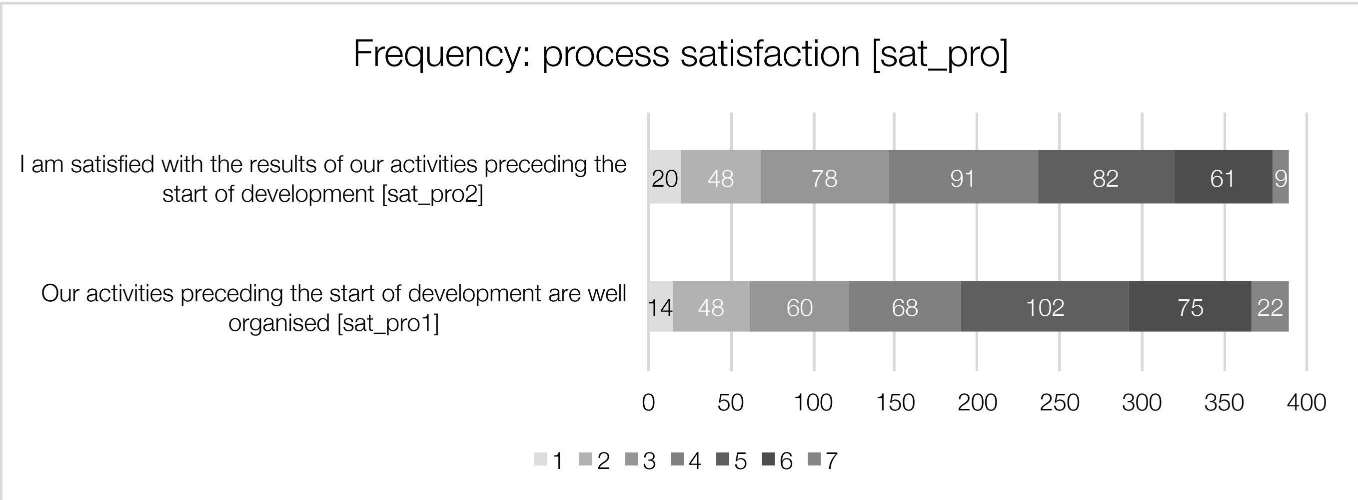


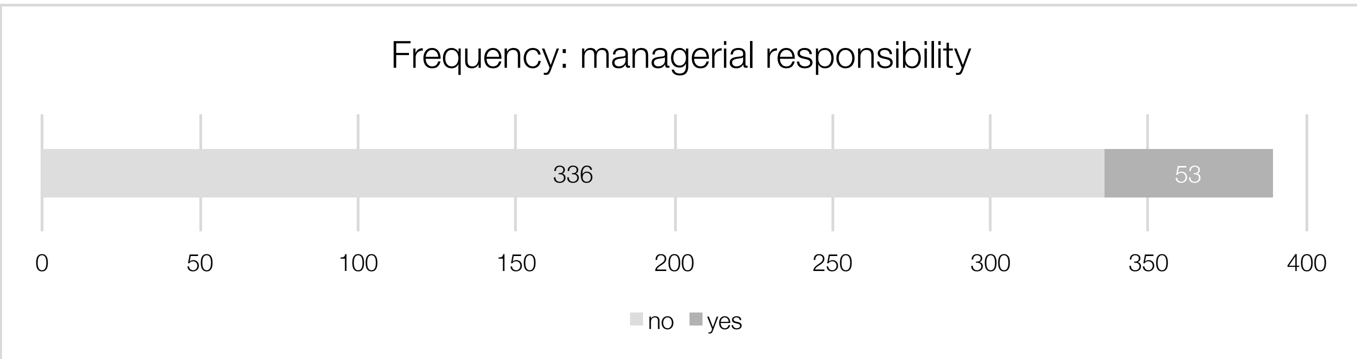
Appendix A07
Frequency Distribution of Imputed Questionnaire Items

Frequency distribution independent variables: external environment



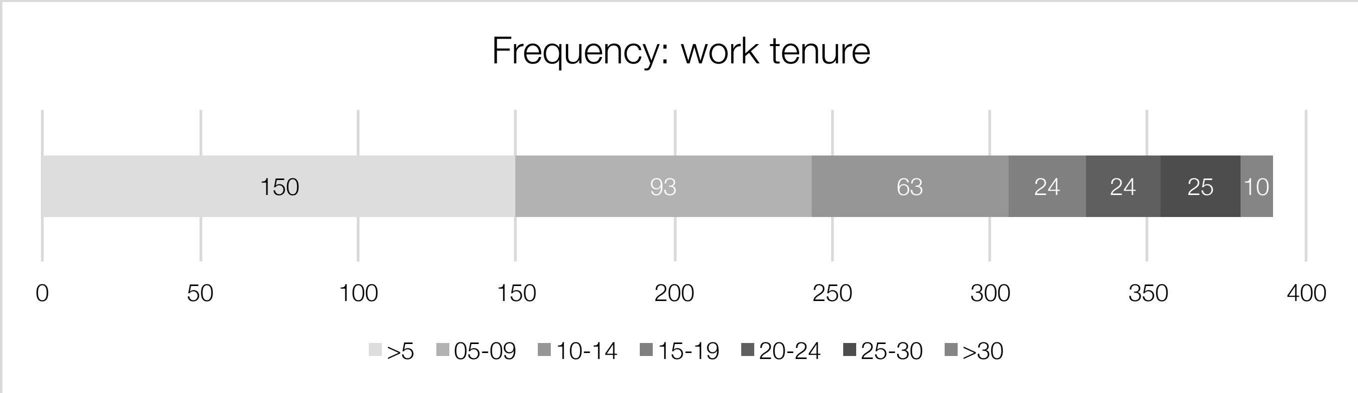
Frequency distribution independent variables: controls

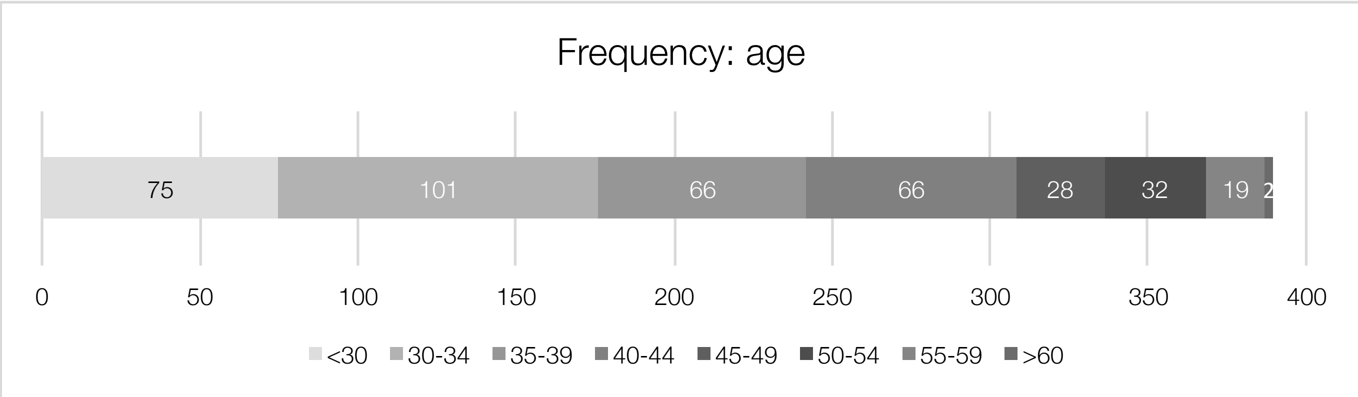




Appendix A07
Frequency Distribution of Imputed Questionnaire Items

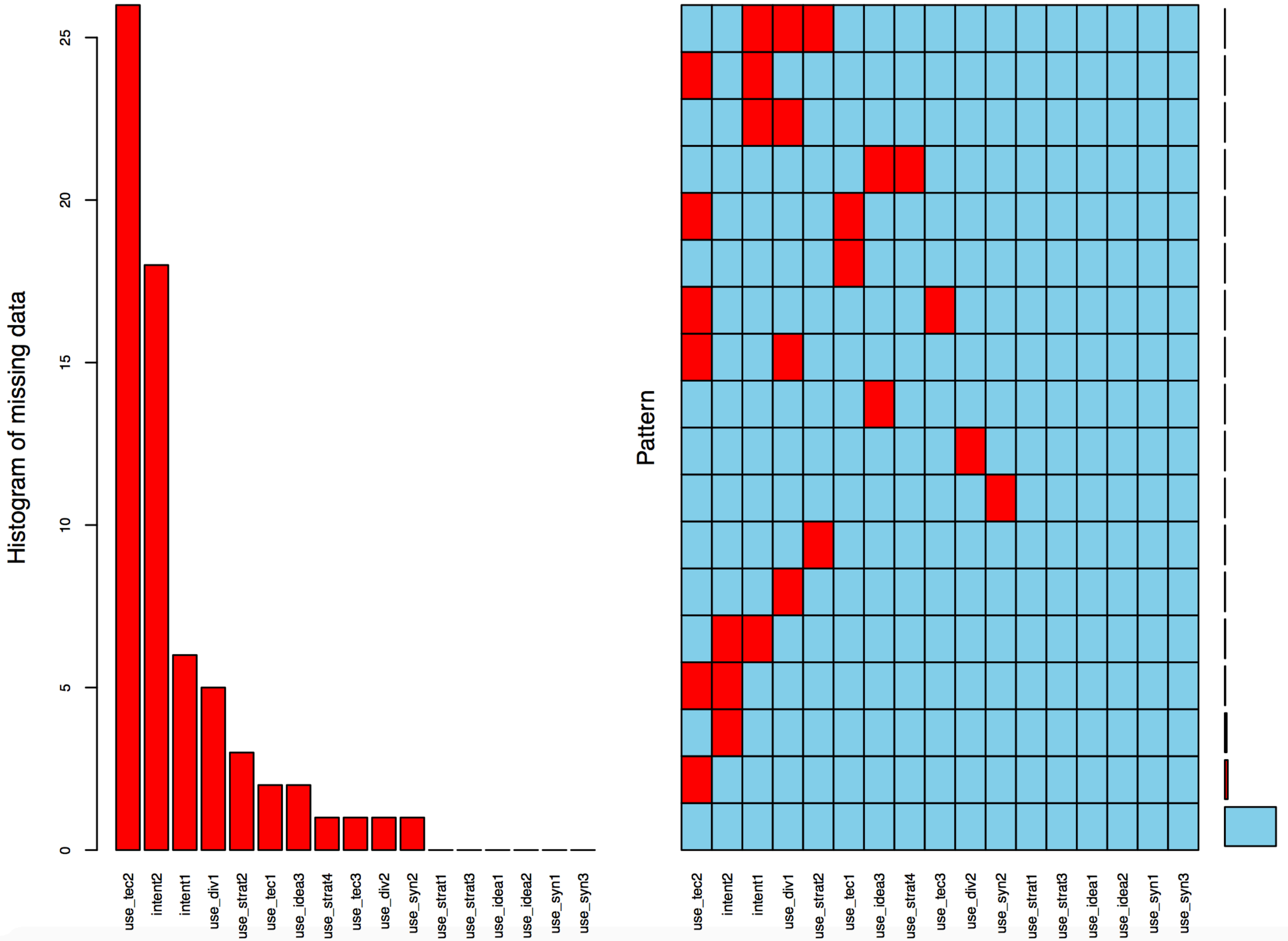
Frequency distribution independent variables: controls





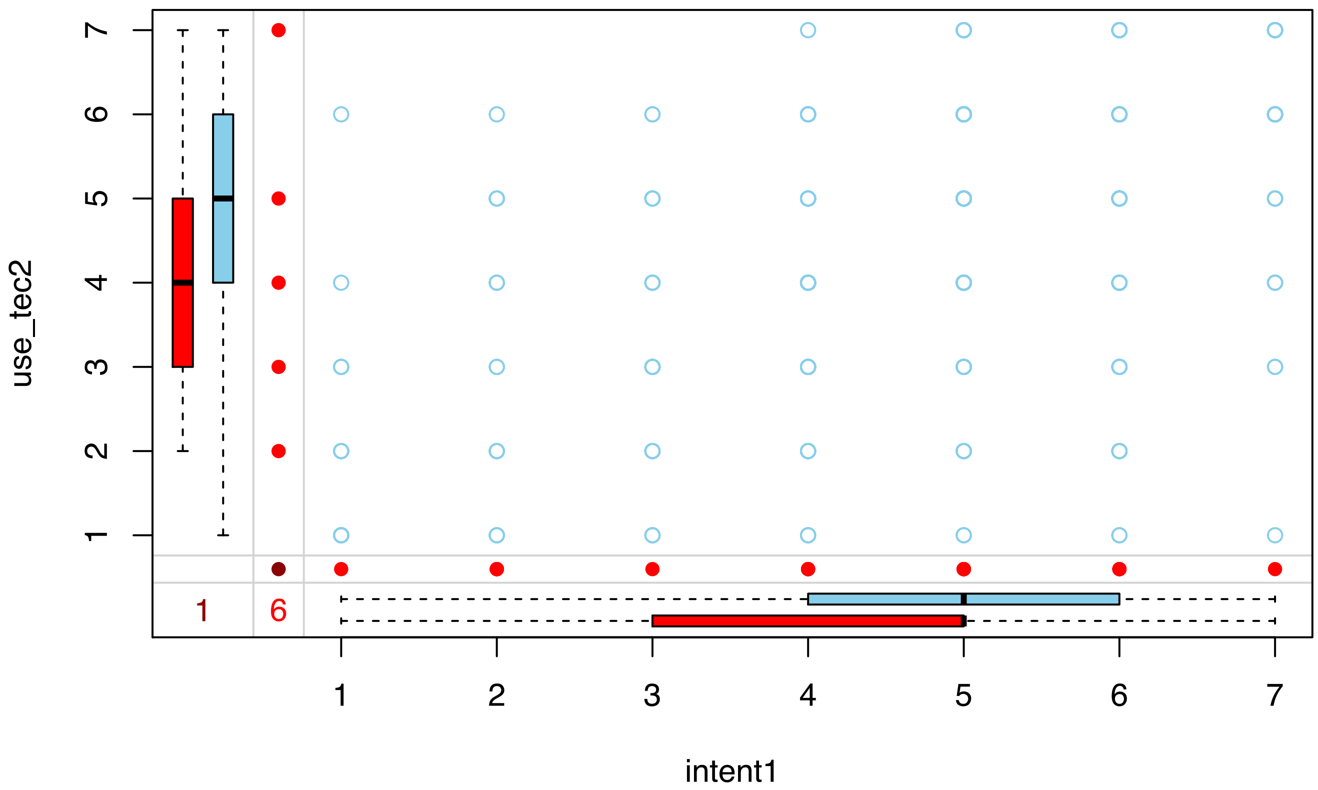
Appendix A08
Missing Data Analysis

Missing patterns of variables: types of applications for innovation fields



Variable	Number or missings
use_tec2	26
intent2	18
intent1	6
use_div1	5
use_strat2	3
use_tec1	2
use_idea3	2
use_strat4	1
use_tec3	1
use_div2	1
use_syn2	1
use_strat1	0
use_strat3	0
use_idea1	0
use_idea2	0
use_syn1	0
use_syn3	0

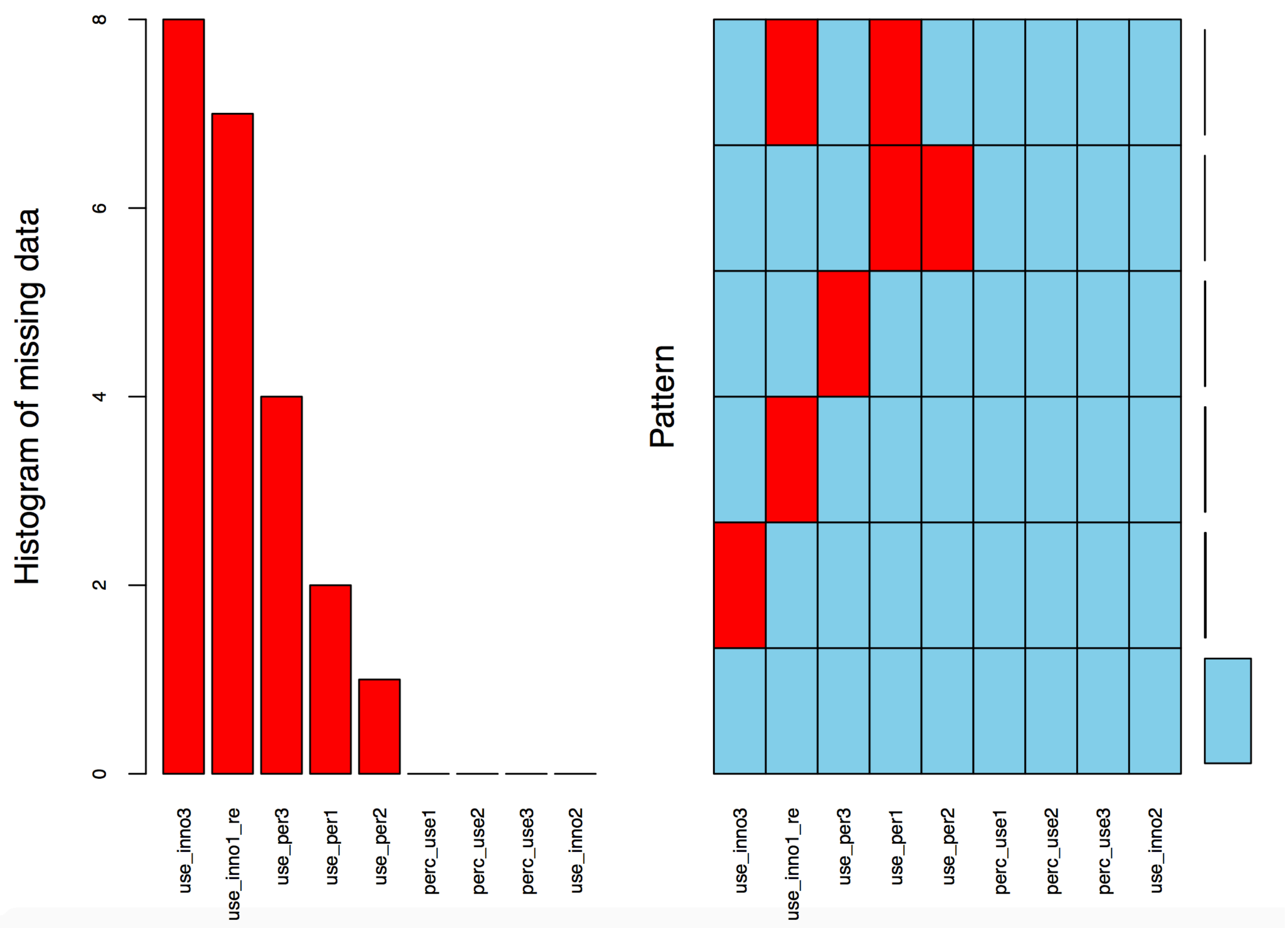
MCAR vs. MAR: types of applications for innovation fields



Missing data is MAR: Distribution of observed values (red box-plots) is not similar to distribution of missing data points (blue box-plots).

Appendix A08
Missing Data Analysis

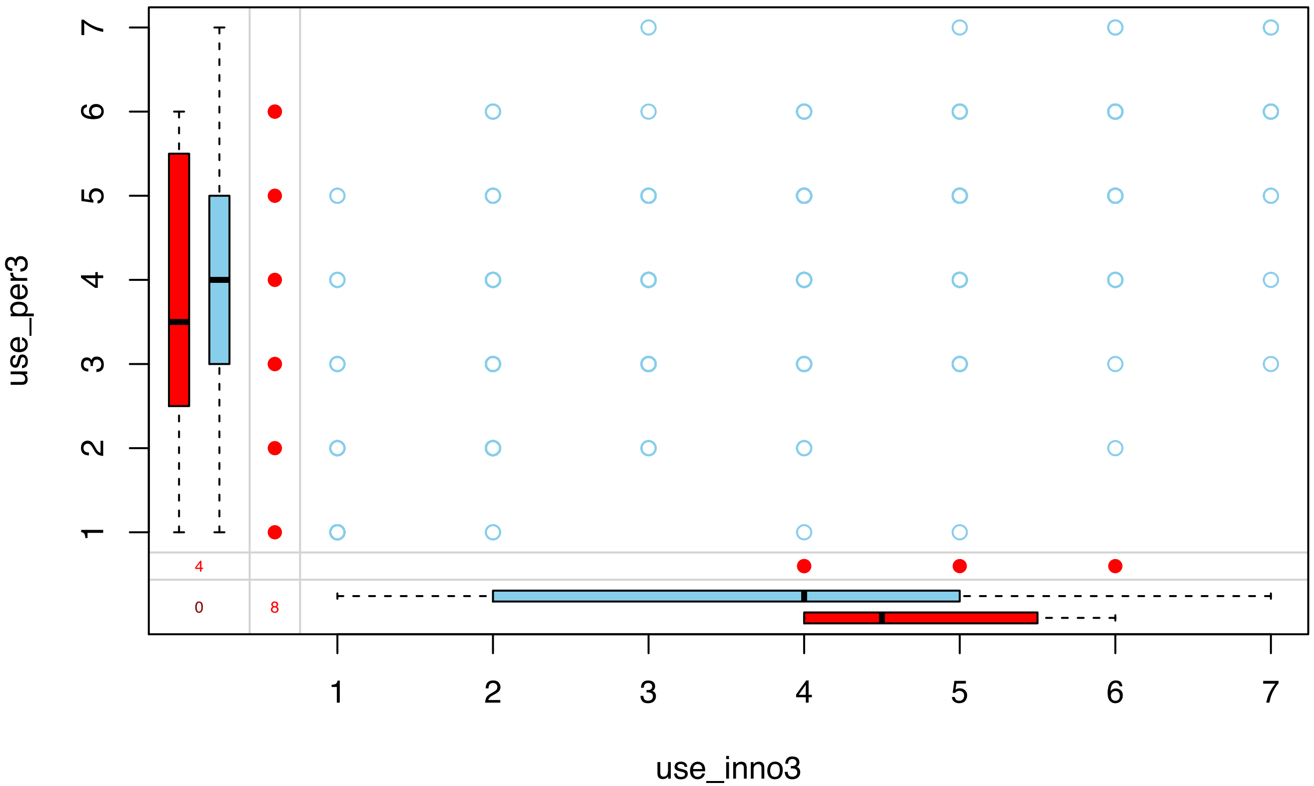
Missing patterns of variables: proficiency-related variables



Variable	Number or missings
use_inno3	8
use_inno1_re	7
use_per3	4
use_per1	2
use_per2	1
perc_use1	0
perc_use2	0
perc_use3	0
use_inno2	0

Appendix A08
Missing Data Analysis

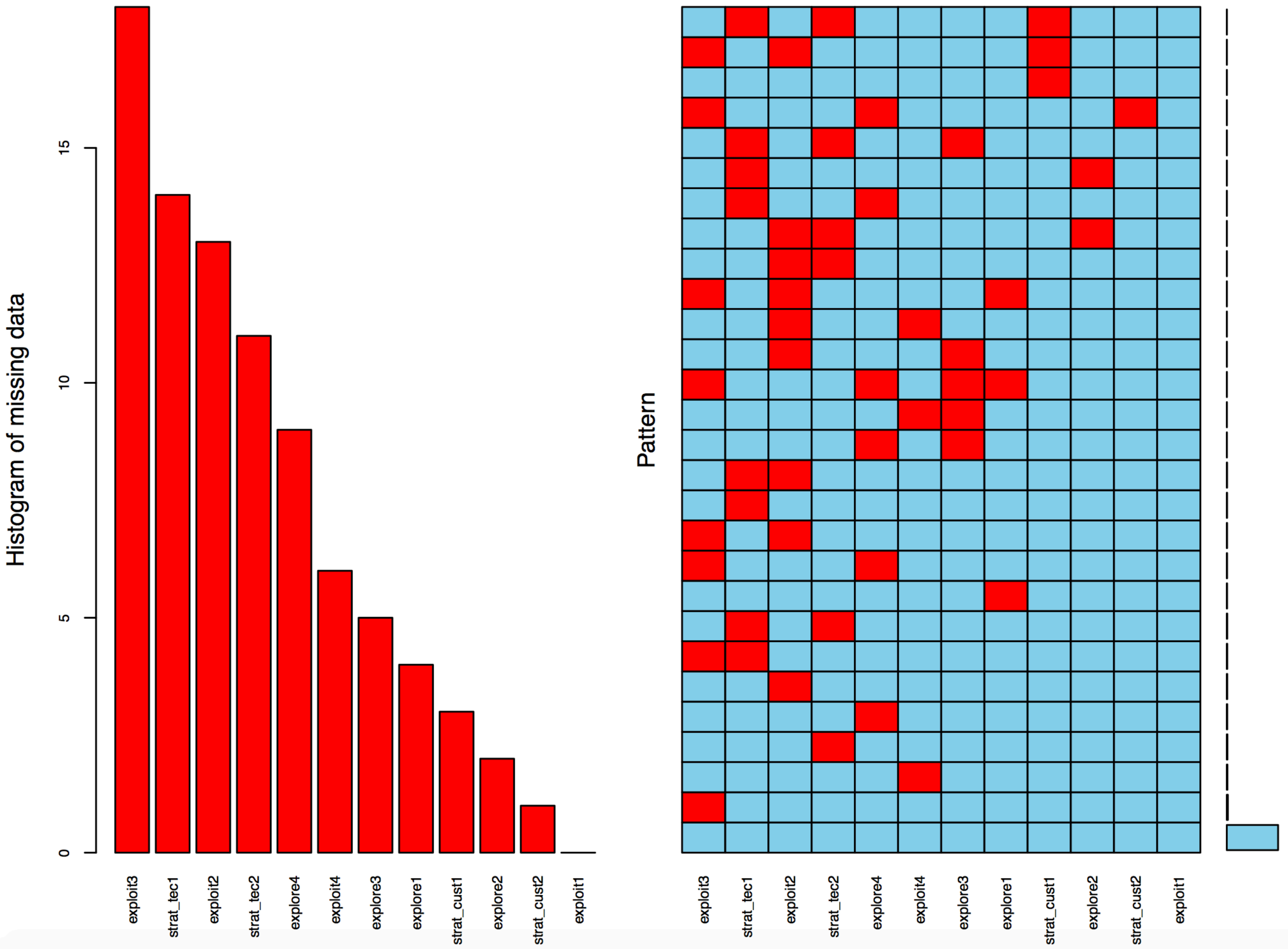
MCAR vs. MAR: proficieny-related variables



Missing data is MAR: Distribution of observed values (red box-plots) is not similar to distribution of missing data points (blue box-plots).

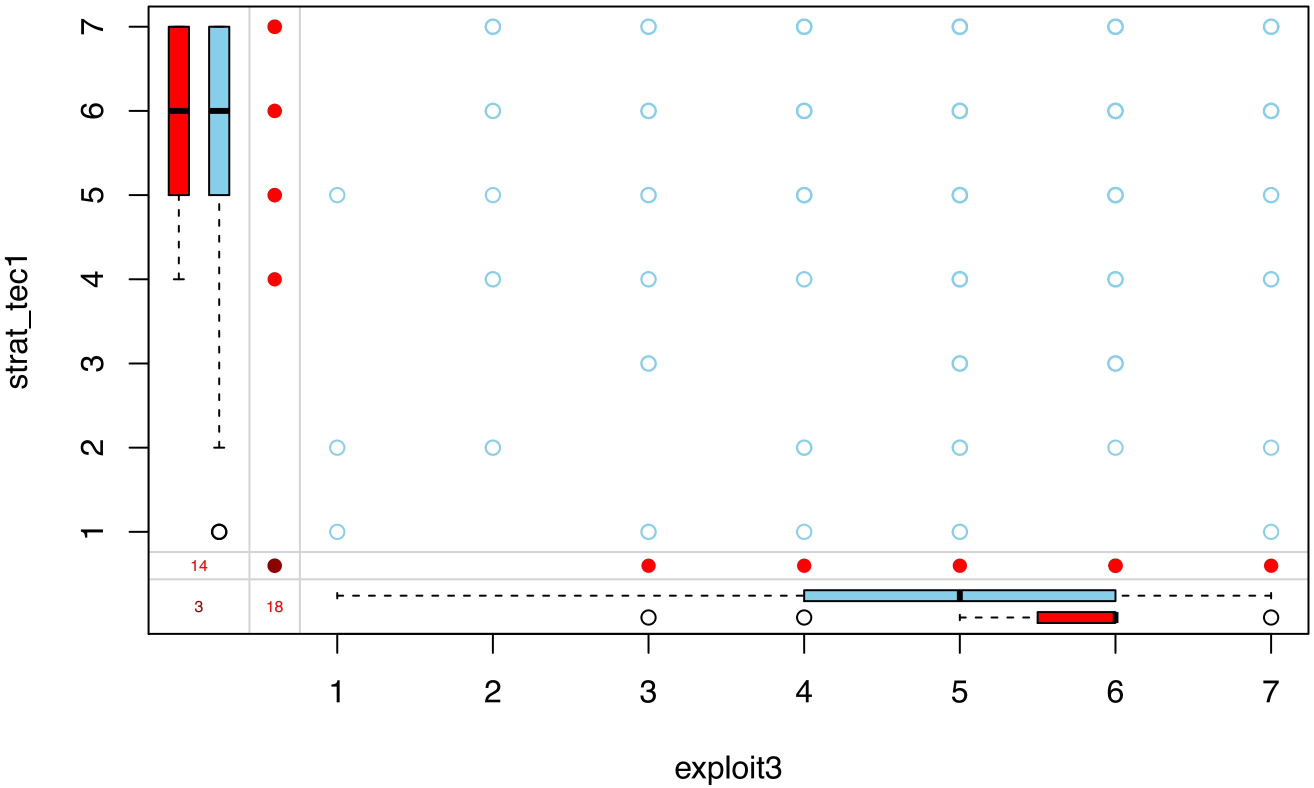
Appendix A08
Missing Data Analysis

Missing patterns of variables: independent variables (strategic orientation)



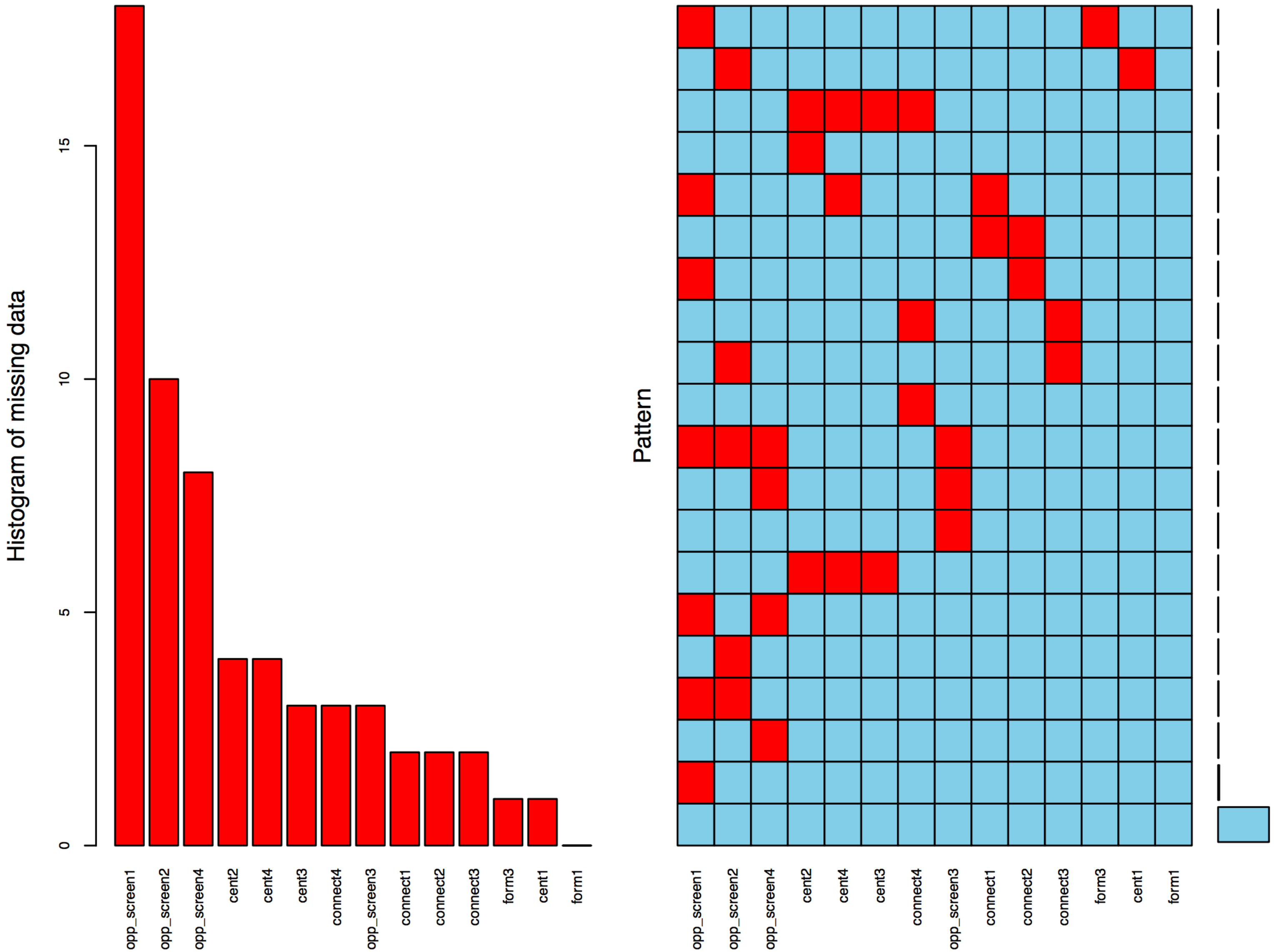
Variable	Number or missings
exploit3	18
strat_tec1	14
exploit2	13
strat_tec2	11
explore4	9
exploit4	6
explore3	5
explore1	4
strat_cust1	3
explore2	2
strat_cust2	1
exploit1	0

MCAR vs. MAR: independent variables (strategic orientation)



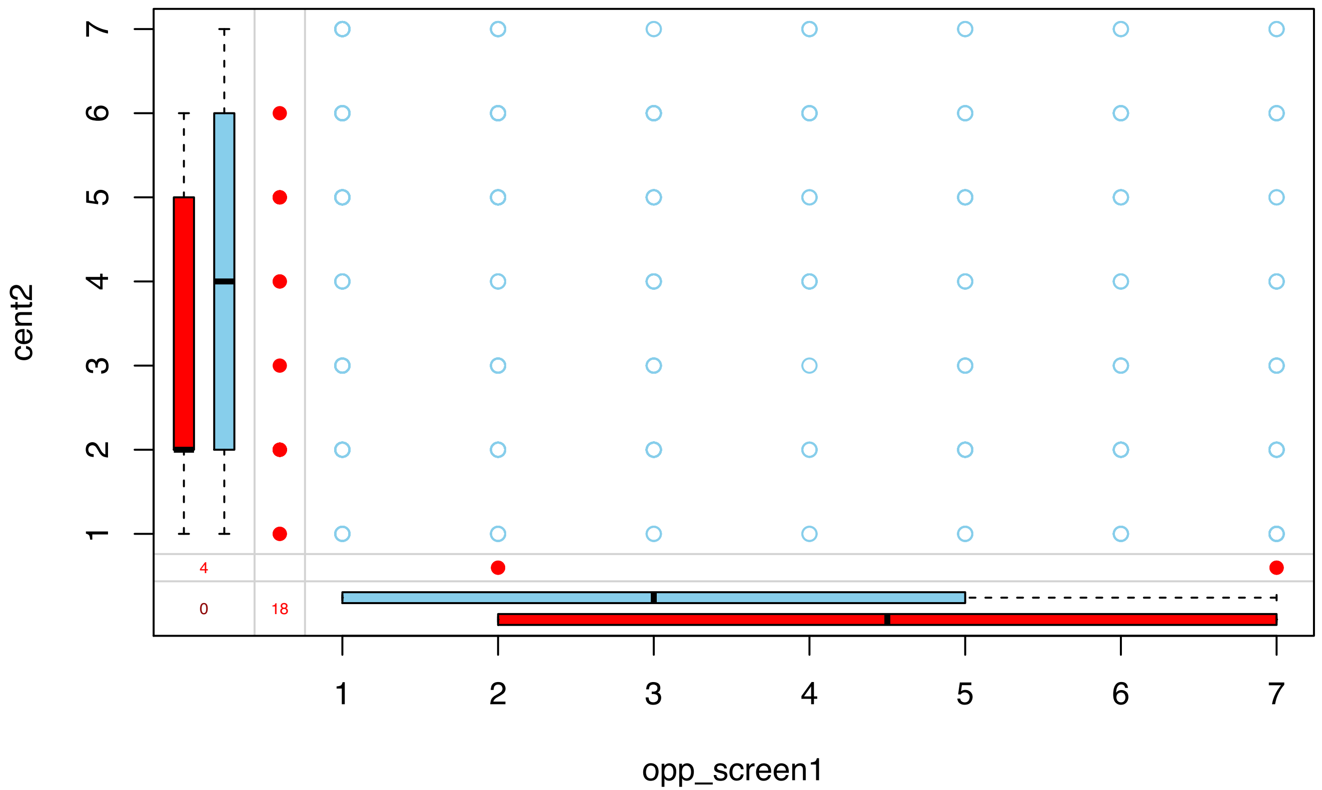
Missing data is MAR: Distribution of observed values (red box-plots) is only similar to distribution of missing data points (blue box-plots) for strat_tec1.

Missing patterns of variables: independent variables (organizational context)



Variable	Number or missings
opp_screen1	18
opp_screen2	10
opp_screen4	8
cent2	4
cent4	4
cent3	3
connect4	3
opp_screen3	3
connect1	2
connect2	2
connect3	2
form3	1
cent1	1
form1	0

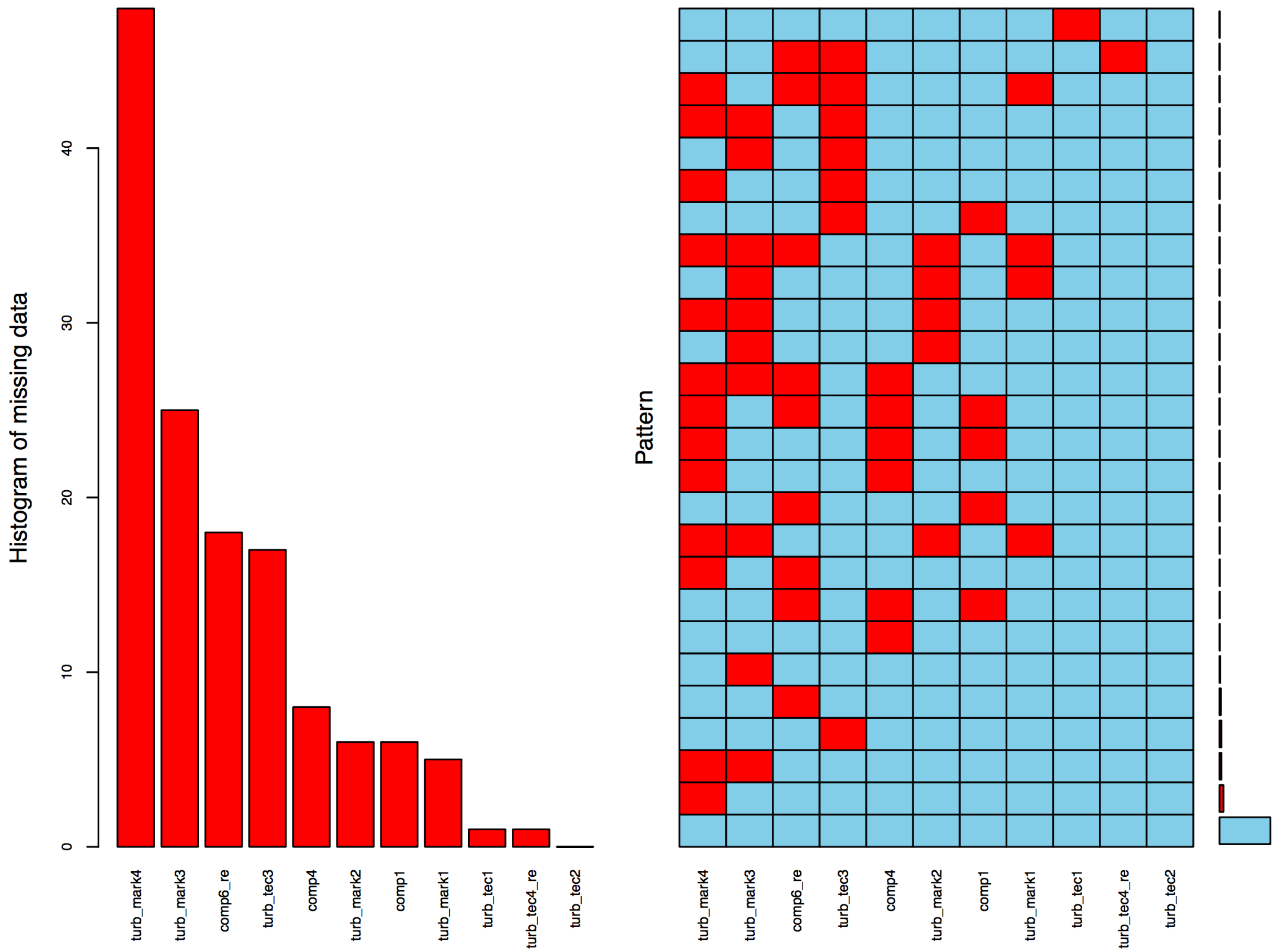
MCAR vs. MAR: independent variables (organizational context)



Missing data is MAR: Distribution of observed values (red box-plots) is not similar to distribution of missing data points (blue box-plots).

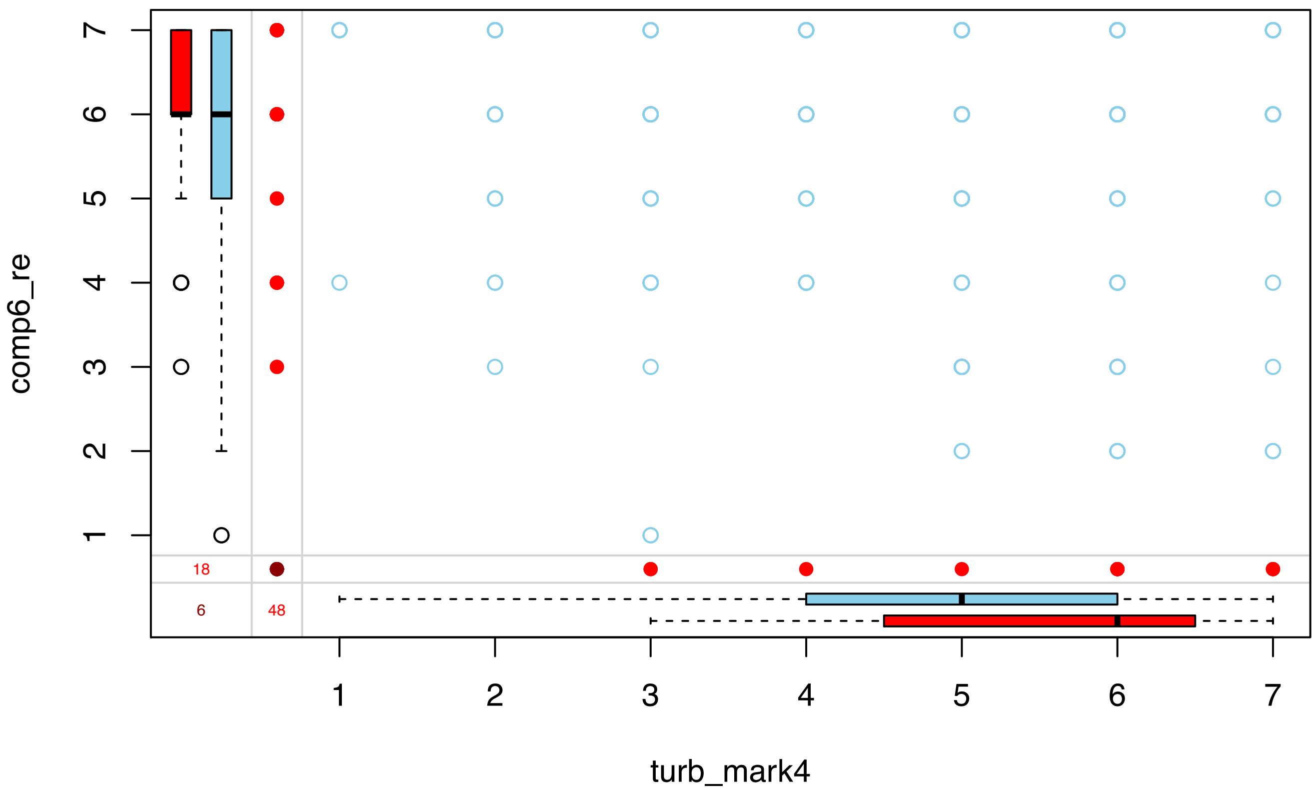
Appendix A08
Missing Data Analysis

Missing patterns of variables: independent variables (external environment)



Variable	Number or missings
turb_mark4	48
turb_mark3	25
comp6_re	18
turb_tec3	17
comp4	8
turb_mark2	6
comp1	6
turb_mark1	5
turb_tec1	1
turb_tec4_re	1
turb_tec2	0

MCAR vs. MAR: independent variables (external environment)



Missing data is MAR: Distribution of observed values (red box-plots) is not similar to distribution of missing data points (blue box-plots).

Appendix A09
Non-Response Bias

t-Test: two-sample assuming unequal variances

exploit3	*Sample 1*	*Sample 2*
Mean	5.056	4.943
Variance	1.680	1.707
Observations	124	122
Hypothesized Mean Difference	0	
df	244	
t Stat	0.686	
P(T<=t) one-tail	0.247	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.493	
t Critical two-tail	1.970	

explore2	*Sample 1*	*Sample 2*
Mean	5.117	5.117
Variance	2.309	2.561
Observations	128	128
Hypothesized Mean Difference	0	
df	253	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.651	
P(T<=t) two-tail	1.000	
t Critical two-tail	1.969	

opp_screen3	*Sample 1*	*Sample 2*
Mean	4.414	4.453
Variance	3.158	3.399
Observations	128	128
Hypothesized Mean Difference	0	
df	254	
t Stat	-0.173	
P(T<=t) one-tail	0.432	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.863	
t Critical two-tail	1.969	

strat_cust1	*Sample 1*	*Sample 2*
Mean	5.406	5.236
Variance	1.849	1.595
Observations	128	127
Hypothesized Mean Difference	0	
df	252	
t Stat	1.035	
P(T<=t) one-tail	0.151	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.302	
t Critical two-tail	1.969	

turb_mark2	*Sample 1*	*Sample 2*
Mean	4.921	5.110
Variance	2.311	2.178
Observations	127	127
Hypothesized Mean Difference	0	
df	252	
t Stat	-1.005	
P(T<=t) one-tail	0.158	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.316	
t Critical two-tail	1.969	

comp1	*Sample 1*	*Sample 2*
Mean	5.738	5.758
Variance	1.187	1.240
Observations	126	128
Hypothesized Mean Difference	0	
df	252	
t Stat	-0.143	
P(T<=t) one-tail	0.443	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.887	
t Critical two-tail	1.969	

Appendix A09
Non-Response Bias

t-Test: two-sample assuming unequal variances

perc_use3	*Sample 1*	*Sample 2*
Mean	4.638	4.620
Variance	2.519	2.519
Observations	127	129
Hypothesized Mean Difference	0	
df	254	
t Stat	0.089	
P(T<=t) one-tail	0.465	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.929	
t Critical two-tail	1.969	

use_idea2	*Sample 1*	*Sample 2*
Mean	4.473	4.388
Variance	2.923	2.739
Observations	129	129
Hypothesized Mean Difference	0	
df	256	
t Stat	0.407	
P(T<=t) one-tail	0.342	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.684	
t Critical two-tail	1.969	

use_tec3	*Sample 1*	*Sample 2*
Mean	4.234	3.953
Variance	2.921	2.842
Observations	128	129
Hypothesized Mean Difference	0	
df	255	
t Stat	1.326	
P(T<=t) one-tail	0.093	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.186	
t Critical two-tail	1.969	

use_per2	*Sample 1*	*Sample 2*
Mean	4.602	4.411
Variance	1.974	2.400
Observations	128	129
Hypothesized Mean Difference	0	
df	253	
t Stat	1.034	
P(T<=t) one-tail	0.151	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.302	
t Critical two-tail	1.969	

use_div1	*Sample 1*	*Sample 2*
Mean	4.563	4.328
Variance	2.280	2.773
Observations	128	128
Hypothesized Mean Difference	0	
df	252	
t Stat	1.180	
P(T<=t) one-tail	0.120	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.239	
t Critical two-tail	1.969	

use_syn1	*Sample 1*	*Sample 2*
Mean	5.132	4.806
Variance	1.834	2.345
Observations	129	129
Hypothesized Mean Difference	0	
df	252	
t Stat	1.809	
P(T<=t) one-tail	0.036	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.072	
t Critical two-tail	1.969	

Appendix A10
Comparison of Imputed and Raw Data

Dependent variables

General intention to use innovation fields [intent]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4	5	4.724	6	7	21

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	4	5	4.712	6	7

Application of innovation fields for strategic purposes [use_strat]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4.667	5.667	5.313	6	7	3

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	4.75	5.5	5.184	6	7

Application of innovation fields for technology intelligence [use_tec]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3.333	4.333	4.284	5.333	7	27

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3.333	4.333	4.242	5.333	7

Application of innovation fields for ideation [use_idea]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3.667	4.667	4.471	5.5	7	2

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3.667	4.667	4.472	5.667	7

Application of innovation fields for portfolio extension [use_div]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3	4	3.896	5	7	6

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3	4	3.893	5	7

Application of innovation fields for lifting synergies [use_syn]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4.333	5.333	4.953	6	7	1

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4.333	5.333	4.952	6	7	

Appendix A10
Comparison of Imputed and Raw Data

Dependent variables

Innovation fields enhancing innovativeness [use_inno]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3	4	3.864	4.667	7	15

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3	4	3.848	4.667	7

Innovation fields enhancing performance [use_per]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3.333	4.667	4.326	5.333	7	6

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3.333	4.667	4.333	5.333	7

Perceived usefulness of innovation fields [perc_use]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3.333	4.333	4.056	5	7	3

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3.333	4.333	4.056	5	7

Independent variables

Customer orientation [strat_cust]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	5	5.5	5.347	6	7	4

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	5	5.5	5.352	6	7

Technology orientation [strat_tec]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1.5	5	6	5.47	6.5	7	20

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1.5	5	6	5.468	6.5	7

Appendix A10
Comparison of Imputed and Raw Data

Independent variables

Exploration [explore]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4.333	5.333	5.04	6	7	10

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	4	5	4.823	5.75	7

Exploitation [exploit]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4	4.667	4.692	5.667	7	27

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	4.25	5	4.845	5.75	7

Technology turbulence [turb_tec]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
2	4.375	5.25	5.067	6	7	18

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
2	4.25	5	5.04	6	7

Competitive intensity [comp]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1.667	5	6	5.752	6.333	7	23

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1.667	5	6	5.715	6.333	7

Market turbulence [turb_mark]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1.333	3.667	4.667	4.571	5.333	7	26

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1.5	4	4.75	4.641	5.5	7

Formalization [form]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4	5	4.92	6	7	1

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	4	5	4.923	6	7

Appendix A10
Comparison of Imputed and Raw Data

Independent variables

Centralization [cent]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	2.125	3.25	3.554	5	7	6

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	2	3.25	3.548	5	7

Connectedness [connect]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	4.167	5.333	4.95	6	7	6

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	4	5	4.759	5.5	7

Opportunity screening [opp_screen]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3.333	4.333	4.367	5.667	7	18

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3	4	4.149	5.25	7

Process satisfaction [sat_pro]

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	3	4	4.143	5	7	29

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1	3	4	4.165	5	7

Age

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
24	31	36	38.09	43.5	63	50

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
23	30	36	37.68	44	62

Work tenure

Without imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
0	3	8	10.2	14.75	37	15

With imputation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
0	2	7	9.339	13	36

Appendix A11
Overview of Regression Models
General intention to use innovation fields

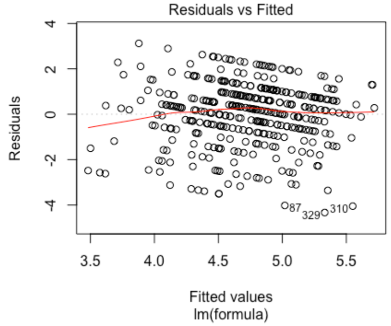
General intention to use innovation fields

Model 1: controls

Dependent variable: general intention to use innovation fields					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.619	0.225	16.11	0.000	***
Process satisfaction	0.266	0.051	5.180	0.000	***
F-statistic: 26.83 on 1 and 378 DF	p-value: 0.000				
Residual standard error: 1.392 on 378 degrees of freedom					
Multiple R^2: 0.06627	**Adjusted R^2: 0.0638**				

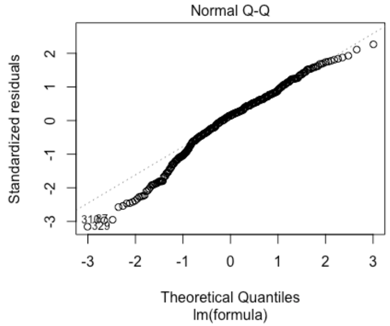
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



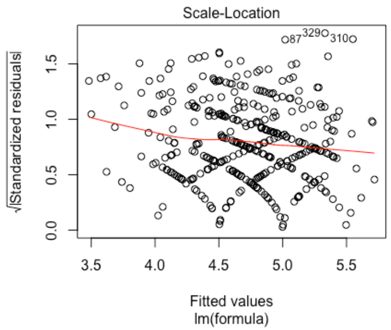
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



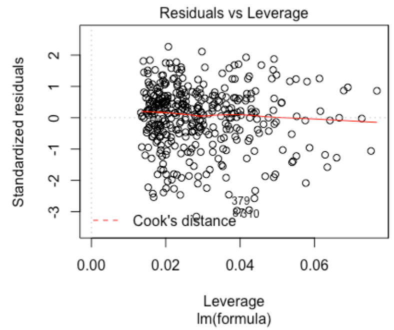
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
General intention to use innovation fields

Model 2: controls & main effects

Dependent variable: general intention to use innovation fields

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	1.3777	0.587	2.347	0.019	*
Competitive intensity	0.1829	0.075	2.447	0.015	*
Customer orientation	0.1255	0.064	1.967	0.050	*
Formalization	-0.0959	0.060	1.600	0.110	
Connectedness	0.1487	0.066	2.264	0.024	*
Opportunity screening	-0.1112	0.057	-1.948	0.052	.
Process satisfaction	0.2188	0.055	3.955	0.000	***
F-statistic: 8.059 on 6 and 373 DF	p-value: 3.383e-08				
Residual standard error: 1.364 on 373 degrees of freedom					
Multiple R^2: 0.1148	**Adjusted R^2: 0.1005**				

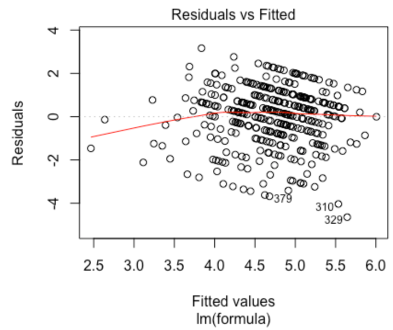
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Competitive intensity	1.0244
Customer orientation	1.1648
Formalization	1.1303
Connectedness	1.1757
Opportunity screening	1.3353
Process satisfaction	1.2036

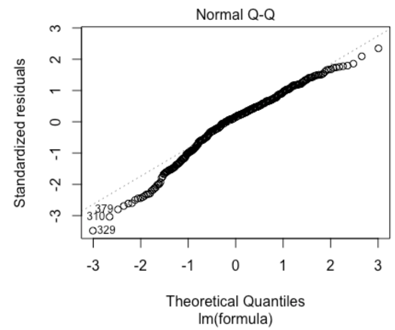
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



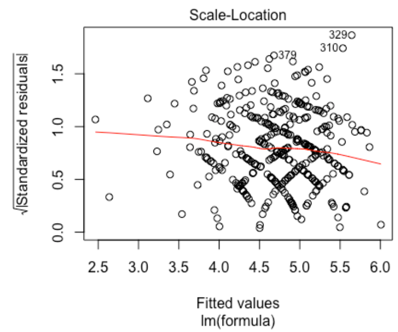
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



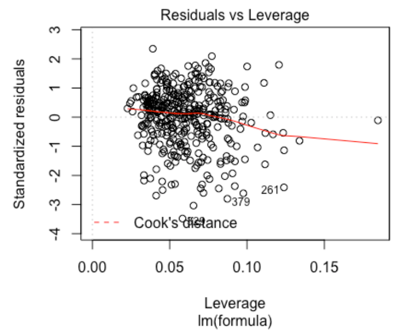
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
General intention to use innovation fields

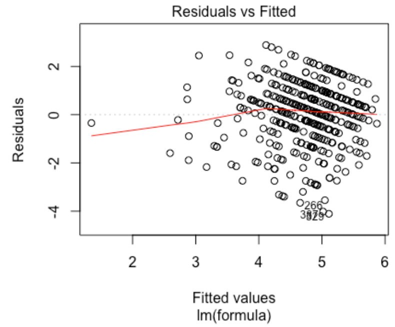
Model 3: controls & quadratic main effects

Dependent variable: general intention to use innovation fields

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	-6.590	2.092	-3.150	0.002	**
Competitive intensity	2.562	0.728	3.517	0.000	***
Customer orientation	0.986	0.383	2.572	0.010	*
Formalization	-0.099	0.059	1.672	0.095	.
Competitive intensity^2	-0.222	0.067	-3.295	0.001	**
Customer orientation^2	-0.086	0.039	-2.204	0.028	*
Opportunity screening^2	-0.015	0.007	-2.326	0.021	*
Connectedness^2	0.018	0.007	2.470	0.014	*
Process satisfaction	0.196	0.054	3.607	0.000	***
F-statistic: 8.611 on 8 and 371 DF	p-value: 0.000				
Residual standard error: 1.335 on 371 degrees of freedom					
Multiple R^2: 0.1566	**Adjusted R^2: 0.1384**				

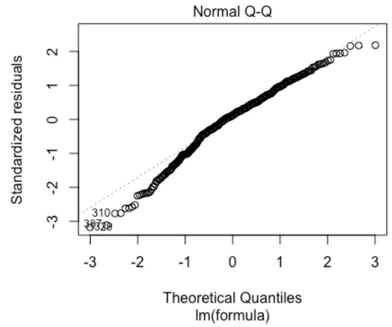
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



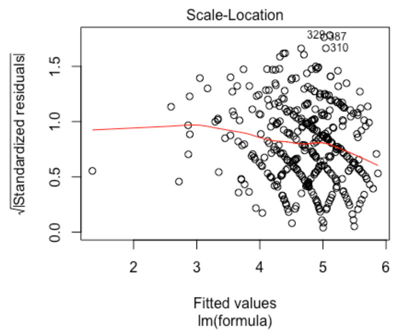
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



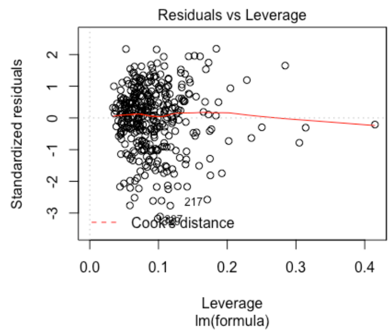
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
General intention to use innovation fields

Final model (including opportunity screening & connectedness)

Controls & quadratic main effects

Dependent variable: general intention to use innovation fields

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	-6.360	2.265	-2.808	0.005	**
Customer orientation	0.978	0.399	2.450	0.015	*
Customer orientation^2	-0.085	0.041	-2.103	0.036	*
Formalization	-0.098	0.059	1.651	0.100	.
Opportunity screening	0.093	0.261	0.357	0.722	
Opportunity screening^2	-0.026	0.031	-0.852	0.395	
Connectedness	-0.148	0.387	-0.382	0.703	
Connectedness^2	0.034	0.043	0.784	0.433	
Competitive intensity	2.540	0.733	3.467	0.001	***
Competitive intensity^2	-0.220	0.068	-3.248	0.001	**
Process satisfaction	0.196	0.055	3.576	0.000	***
F-statistic: 6.881 on 10 and 369 DF		p-value: 6.971e-10			
Residual standard error: 1.339 on 369 degrees of freedom					
Multiple R^2: 0.1572		**Adjusted R^2: 0.1343**			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Calculation of inflection points

	Coefficients	Inflection point
Competitive intensity	2.560	
Competitive intensity^2	-0.223	5.741
Customer orientation	0.988	
Customer orientation^2	-0.086	5.774
Opportunity screening	0.123	
Opportunity screening^2	-0.030	2.069
Connectedness	-0.200	
Connectedness^2	0.038	2.647

Likelihood ratio test: opportunity screening

Model 1: including opportunity screening
Model 2: excluding opportunity screening

	#Df	LogLik	Df	Chisq	Pr(>Chisq)	Sig
1	11	-644.5				
2	9	-647.3	-2	5.6072	0.06059	.

Likelihood ratio test: connectedness

Model 1: including connectedness
Model 2: excluding connectedness

	#Df	LogLik	Df	Chisq	Pr(>Chisq)	Sig
1	12	-644.43				
2	10	-647.56	-2	6.27	0.0435	*

Both variables are included in the regressiion model.

Appendix A11
Overview of Regression Models
Application of innovation fields for strategic purposes

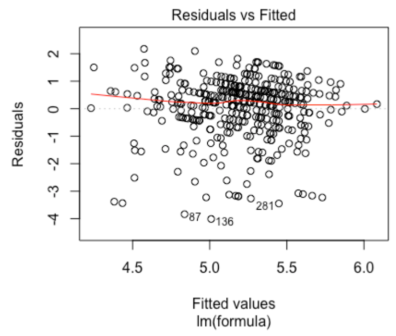
Application of innovation fields for strategic purposes

Model 1: controls

Dependent variable: application of innovation fields for strategic purposes					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	4.887	0.249	19.610	0	***
Responsibility	-0.339	0.172	-1.976	0.049	*
Process satisfaction	0.169	0.042	3.999	0.000	***
F-statistic: 9.015 on 2 and 377 DF	p-value: 0.0001499				
Residual standard error: 1.129 on 377 degrees of freedom					
Multiple R^2: 0.04564	**Adjusted R^2: 0.04058**				

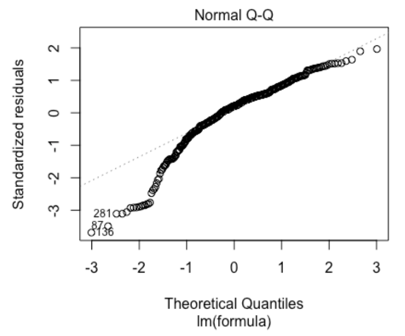
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



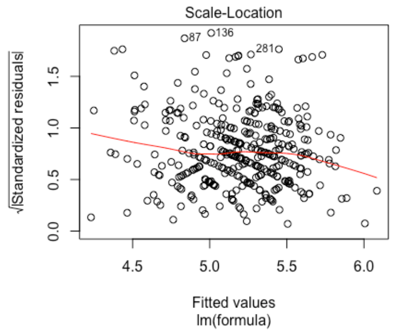
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



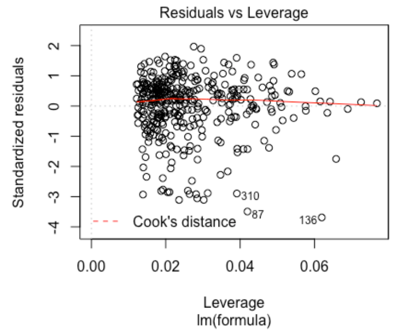
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for strategic purposes

Model 2: controls & main effects

Dependent variable: application of innovation fields for strategic purposes					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.317	0.469	7.072	0.000	***
Competitive intensity	0.118	0.060	1.951	0.052	.
Formalization	-0.098	0.048	2.045	0.042	*
Connectedness	0.145	0.051	2.858	0.005	**
Responsibility	-0.390	0.169	-2.304	0.022	*
Process satisfaction	0.115	0.043	2.638	0.009	**
F-statistic: 7.466 on 5 and 374 DF	p-value: 1.078e-06				
Residual standard error: 1.106 on 374 degrees of freedom					
Multiple R^2: 0.09076	**Adjusted R^2: 0.0786**				

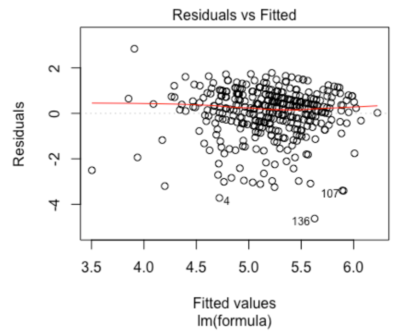
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Competitive intensity	1.0197
Formalization	1.1024
Connectedness	1.0756
Responsibility	1.0352
Process satisfaction	1.1319

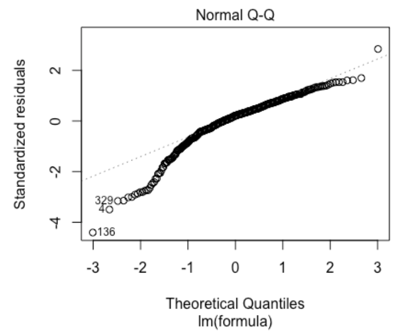
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



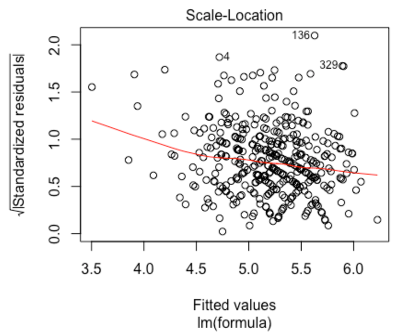
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage

No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for strategic purposes

Final model

Controls & quadratic main effects

Dependent variable: application of innovation fields for strategic purposes

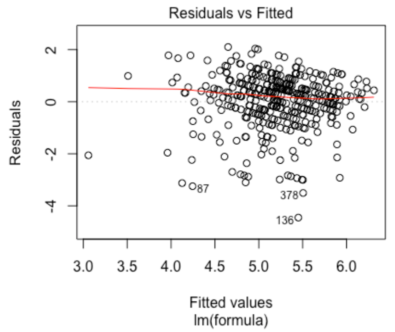
	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	-0.484	1.837	-0.263	0.793	
Customer orientation	0.625	0.317	1.971	0.050	*
Customer orientation^2	-0.056	0.032	-1.746	0.082	.
Formalization	-0.089	0.048	1.867	0.063	.
Connectedness	-0.499	0.313	-1.594	0.112	
Connectedness^2	0.071	0.034	2.056	0.041	*
Competitive intensity	1.538	0.595	2.584	0.010	*
Competitive intensity^2	-0.134	0.055	-2.428	0.016	*
Process satisfaction	0.096	0.044	2.172	0.031	*
Responsibility	-0.385	0.167	-2.305	0.022	*
F-statistic: 5.993 on 9 and 370 DF	p-value: 7.554e-08				
Residual standard error: 1.09 on 370 degrees of freedom					
Multiple R^2: 0.1272	**Adjusted R^2: 0.106**				

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Calculation of inflection points

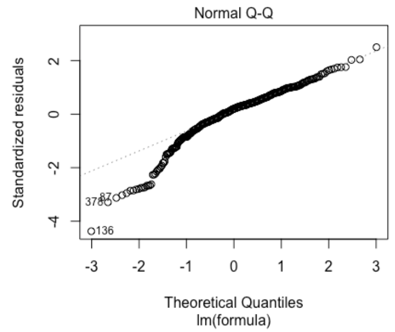
	Coefficients	Inflection point
Competitive intensity	1.562	
Competitive intensity^2	-0.137	5.712
Customer orientation	0.614	
Customer orientation^2	-0.054	5.645
Connectedness	-0.529	
Connectedness^2	0.073	3.624

Residuals Fitted Plot



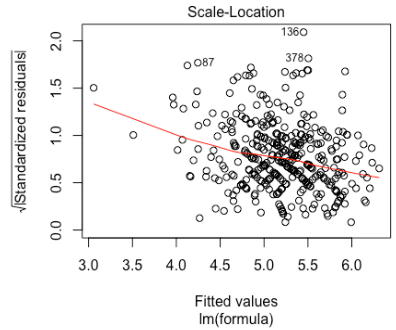
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



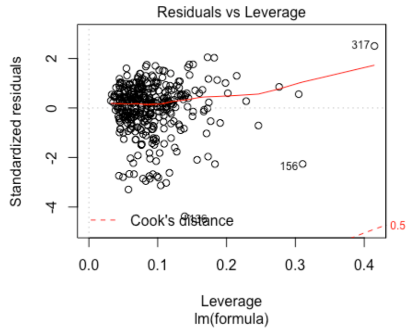
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for ideation

Application of innovation fields for ideation

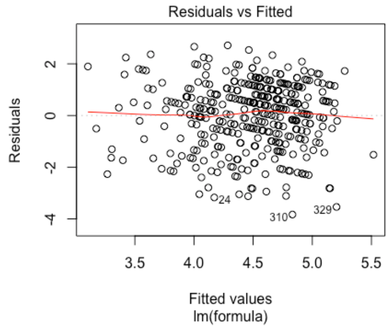
Model 1: controls

Dependent variable: application of innovation fields for ideation

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	4.178	0.306	13.672	0.000	***
Unit 2: Software Systems	-0.756	0.231	-3.278	0.001	**
Unit 3: Consumer Goods	0.082	0.325	0.251	0.802	
Unit 4: Materials & Sensors	-0.091	0.222	-0.412	0.680	
Unit 5: Components	-0.069	0.244	-0.282	0.778	
Unit 6: Manufacturing Tech.	-0.255	0.222	-1.152	0.250	
Responsibility	-0.369	0.200	-1.843	0.066	.
Process satisfaction	0.227	0.051	4.494	0.000	***
F-statistic: 5.699 on 7 and 372 DF	p-value: 2.844e-06				
Residual standard error: 1.299 on 372 degrees of freedom					
Multiple R^2: 0.09685	**Adjusted R^2: 0.07985**				

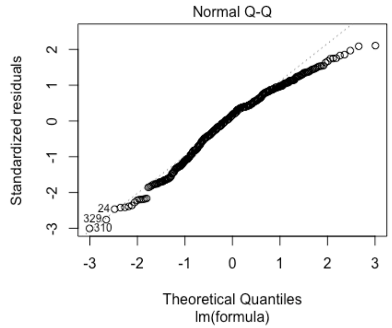
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



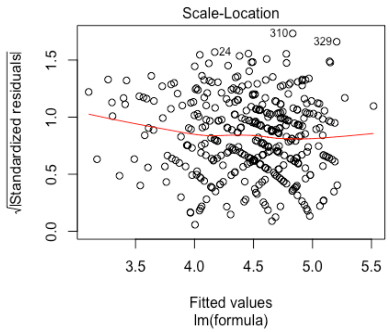
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



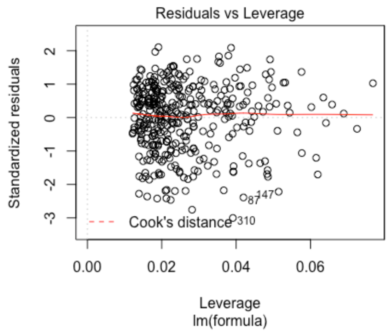
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for ideation

Model 2: controls & main effects

Dependent variable: application of innovation fields for ideation

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	2.901	0.731	3.968	0.000	***
Technology turbulence	0.123	0.070	1.748	0.081	.
Competitive intensity	-0.117	0.075	-1.561	0.119	
Centralization	0.073	0.044	1.671	0.096	.
Connectedness	0.094	0.061	1.556	0.120	
Exploitation	0.118	0.068	1.729	0.085	.
Unit 2: Software Systems	-0.779	0.235	-3.312	0.001	**
Unit 3: Consumer Goods	0.261	0.334	0.780	0.436	
Unit 4: Materials & Sensors	-0.138	0.221	-0.625	0.532	
Unit 5: Components	-0.077	0.247	-0.312	0.755	
Unit 6: Manufacturing Tech.	-0.220	0.232	-0.948	0.344	
Responsibility	-0.299	0.203	-1.475	0.141	
Process satisfaction	0.220	0.053	4.110	0.000	***
F-statistic: 4.479 on 12 and 367 DF	p-value: 9.962e-07				
Residual standard error: 1.285 on 367 degrees of freedom					
Multiple R^2: 0.1277	**Adjusted R^2: 0.09923**				

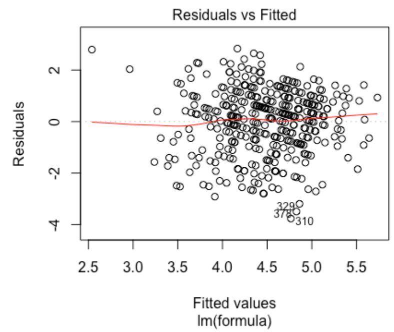
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Technology turbulence	1.3484
Competitive intensity	1.1542
Centralization	1.1987
Connectedness	1.1256
Exploitation	1.1116
Unit factor	1.4606
Responsibility	1.0968
Process satisfaction	1.2651

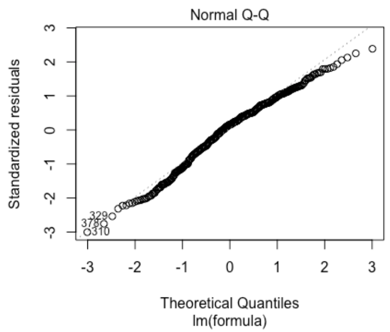
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



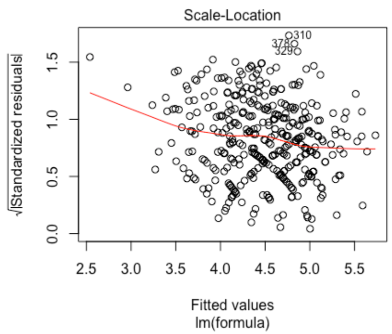
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



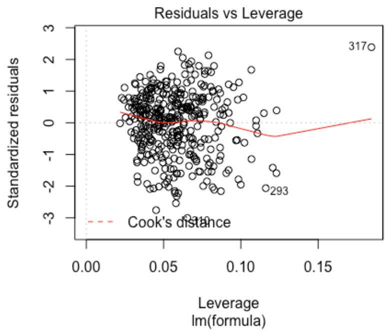
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

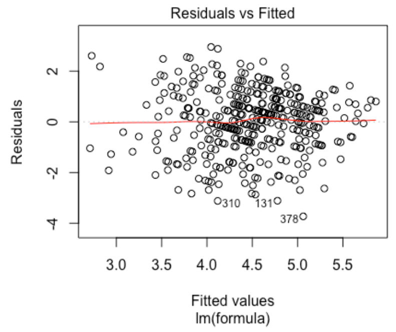
Appendix A11
Overview of Regression Models
Application of innovation fields for ideation

Model 3: controls & quadratic main effects

Dependent variable: application of innovation fields for ideation					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-2.856	1.992	-1.434	0.152	
Technology turbulence	0.115	0.078	1.481	0.140	
Competitive intensity	1.487	0.703	2.116	0.035	*
Market turbulence	0.817	0.444	1.840	0.067	.
Centralization	0.074	0.043	1.719	0.087	.
Exploitation	0.129	0.067	1.918	0.056	.
Competittive intensity^2	-0.148	0.065	-2.275	0.024	*
Market turbulence^2	-0.092	0.049	-1.858	0.064	.
Connectedness^2	0.013	0.007	1.900	0.058	.
Unit 2: Software Systems	-0.743	0.233	-3.189	0.002	**
Unit 3: Consumer Goods	0.308	0.335	0.922	0.357	
Unit 4: Materials & Sensors	-0.113	0.219	-0.517	0.605	
Unit 5: Components	-0.068	0.247	-0.274	0.784	
Unit 6: Manufacturing Tech.	-0.248	0.230	-1.079	0.282	
Responsibility	-0.320	0.200	-1.596	0.111	
Process satisfaction	0.216	0.053	4.095	0.000	***
F-statistic: 4.452 on 15 and 364 DF	p-value: 9.756e-08				
Residual standard error: 1.27 on 364 degrees of freedom					
Multiple R^2: 0.155	**Adjusted R^2: 0.1202**				

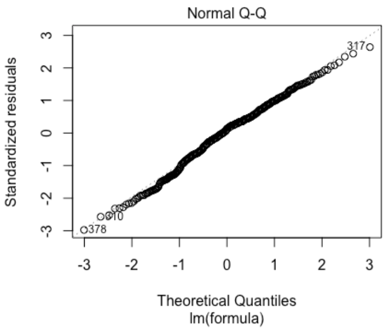
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



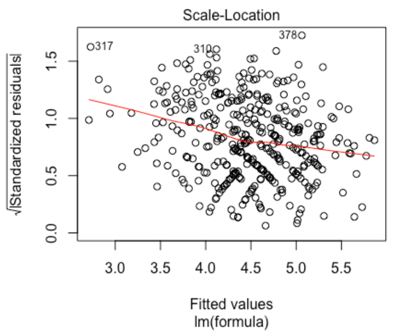
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



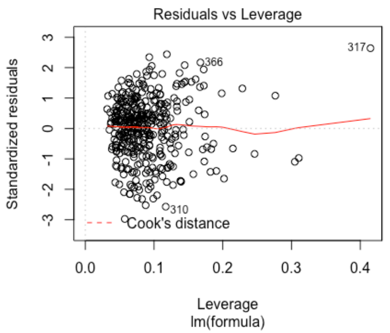
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11

Overview of Regression Models

Application of innovation fields for ideation

Final model (including connectedness)

Controls & quadratic main effects

Dependent variable: application of innovation fields for ideation

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-1.803	2.170	-0.831	0.407	
Exploitation	0.131	0.067	1.946	0.052	.
Centralization	0.076	0.043	1.754	0.080	.
Connectedness	-0.444	0.364	-1.218	0.224	
Connectedness^2	0.061	0.040	1.514	0.131	
Technology turbulence	0.114	0.078	1.468	0.143	
Competitive intensity	1.423	0.704	2.021	0.044	*
Competittive intensity^2	-0.142	0.065	-2.183	0.030	*
Market turbulence	0.839	0.444	1.889	0.060	.
Market turbulence^2	-0.095	0.049	-1.913	0.057	.
Unit 2: Software Systems	-0.759	0.233	-3.253	0.001	**
Unit 3: Consumer Goods	0.316	0.334	0.946	0.345	
Unit 4: Materials & Sensors	-0.117	0.219	-0.534	0.594	
Unit 5: Components	-0.075	0.247	-0.302	0.763	
Unit 6: Manufacturing Tech.	-0.279	0.232	-1.206	0.229	
Process satisfaction	0.225	0.053	4.219	0.000	***
Responsibility	-0.309	0.200	-1.542	0.124	
F-statistic: 4.272 on 16 and 363 DF	p-value: 1.18e-07				
Residual standard error: 1.269 on 363 degrees of freedom					
Multiple R^2: 0.1585	**Adjusted R^2: 0.1214**				

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Calculation of inflection points

	Coefficients	Inflection point
Competitive intensity	1.480	
Competittive intensity^2	-0.146	5.065
Market turbulence	0.801	
Market turbulence^2	-0.091	4.393
Connectedness	-0.404	
Connectedness^2	0.058	3.515

Likelihood ratio test: connectedness

Model 1: including connectedness

Model 2: excluding connectedness

	#Df	**LogLik**	**Df**	**Chisq**	**Pr(>Chisq)**	**Sig**
1	18	-621.09				
2	16	-623.74	-2	5.2989	0.07069	.

Appendix A11
Overview of Regression Models
Application of innovation fields for lifting synergies

Application of innovation fields for lifting synergies

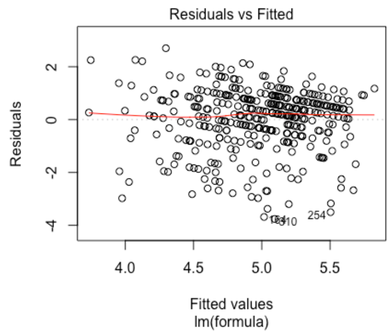
Model 1: controls

Dependent variable: application of innovation fields for lifting synergies

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	4.831	0.275	17.593	0.000	***
Unit 2: Software Systems	-0.575	0.207	-2.775	0.006	**
Unit 3: Consumer Goods	-0.272	0.292	-0.931	0.353	
Unit 4: Materials & Sensors	-0.072	0.199	-0.363	0.717	
Unit 5: Components	-0.297	0.220	-1.352	0.177	
Unit 6: Manufacturing Tech.	-0.124	0.199	-0.621	0.535	
Responsibility	-0.483	0.180	-2.685	0.008	**
Process satisfaction	0.217	0.045	4.772	0.000	***
F-statistic: 6.235 on 7 and 372 DF	p-value: 6.362e-07				
Residual standard error: 1.167 on 372 degrees of freedom					
Multiple R^2: 0.105	**Adjusted R^2: 0.08817**				

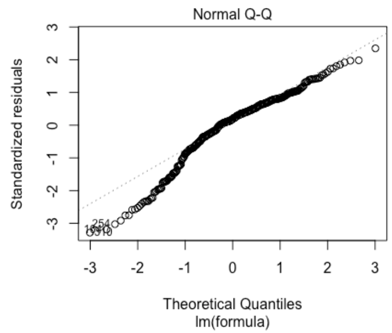
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



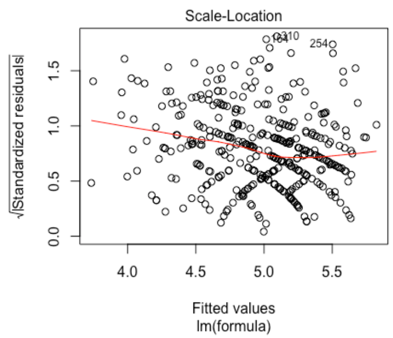
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



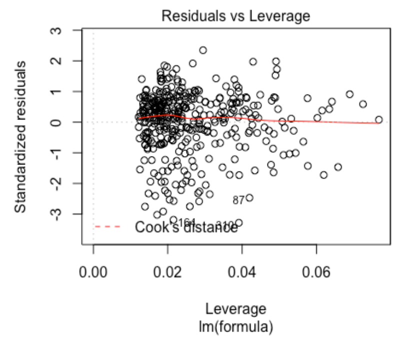
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for lifting synergies

Final model

Controls & main effects

Dependent variable: application of innovation fields for lifting synergies					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.946	0.383	10.314	0.000	***
Exploration	0.139	0.057	2.459	0.014	*
Technology turbulence	0.106	0.063	1.692	0.092	.
Unit 2: Software Systems	-0.620	0.205	-3.022	0.003	**
Unit 3: Consumer Goods	-0.245	0.298	-0.821	0.412	
Unit 4: Materials & Sensors	-0.098	0.197	-0.496	0.620	
Unit 5: Components	-0.251	0.220	-1.140	0.255	
Unit 6: Manufacturing Tech.	-0.037	0.203	-0.181	0.856	
Process satisfaction	0.151	0.049	3.091	0.002	**
Responsibility	-0.536	0.178	-3.006	0.003	**
F-statistic: 6.472 on 9 and 370 DF		p-value: 1.455e-08			
Residual standard error: 1.15 on 370 degrees of freedom					
Multiple R^2: 0.136		**Adjusted R^2: 0.115**			

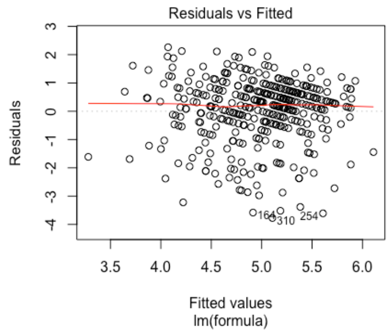
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Technology turbulence	1.3323
Exploration	1.4040
Unit factor	1.3014
Responsibility	1.0611
Process satisfaction	1.3138

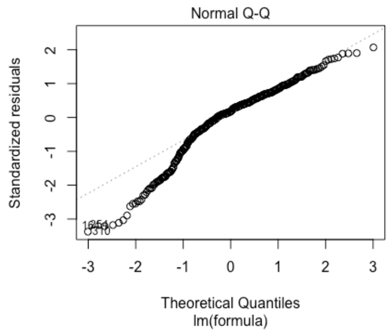
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



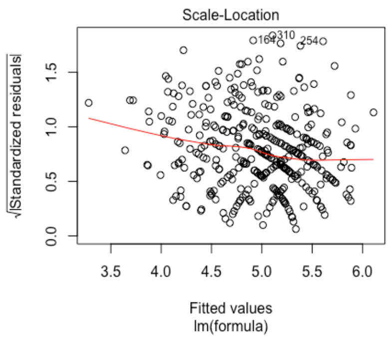
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



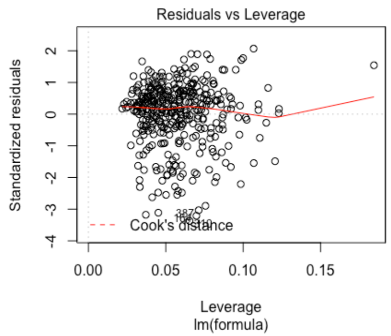
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for lifting synergies

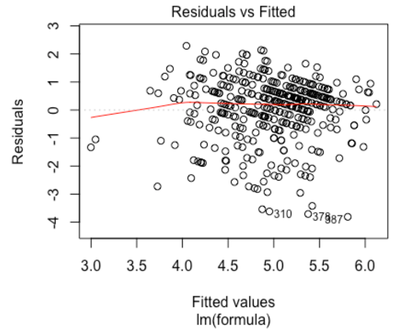
Model 3: ontrols & quadratic main effects

Dependent variable: application of innovation fields for lifting synergies

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	1.129	1.663	0.679	0.498	
Competitive intensity	1.097	0.620	1.770	0.078	.
Exploration	0.109	0.059	1.840	0.067	.
Technology turbulence^2	0.010	0.007	1.490	0.137	
Competitive intensity^2	-0.097	0.057	-1.690	0.092	.
Connectedness^2	0.010	0.006	1.565	0.119	
Unit 2: Software Systems	-0.546	0.209	-2.611	0.009	**
Unit 3: Consumer Goods	-0.249	0.296	-0.840	0.402	
Unit 4: Materials & Sensors	-0.061	0.198	-0.306	0.760	
Unit 5: Components	-0.211	0.220	-0.955	0.340	
Unit 6: Manufacturing Tech.	0.017	0.206	0.080	0.936	
Responsibility	-0.563	0.179	-3.153	0.002	**
Process satisfaction	0.144	0.049	2.955	0.003	**
F-statistic: 5.404 on 12 and 367 DF	p-value: 1.815e-08				
Residual standard error: 1.145 on 367 degrees of freedom					
Multiple R^2: 0.1502	**Adjusted R^2: 0.1224**				

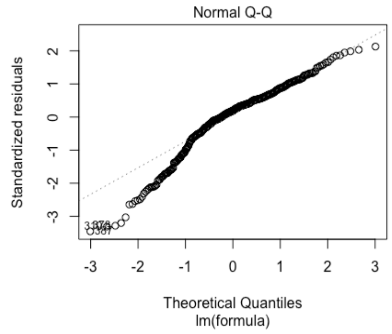
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



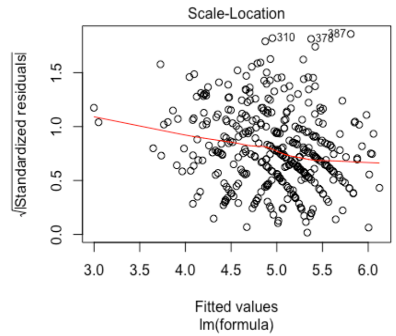
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



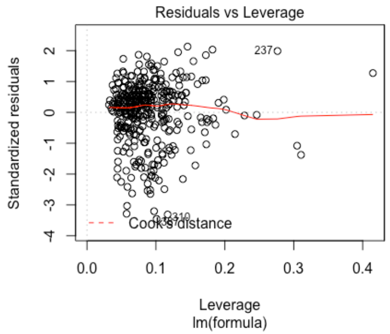
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for technology intelligence

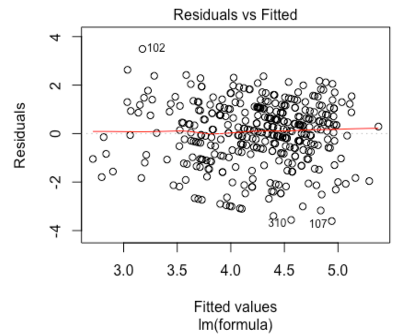
Application of innovation fields for technology intelligence

Model 1: controls

Dependent variable: application of innovation fields for technology intelligence					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.758	0.305	12.319	0.000	***
Unit 2: Software Systems	-0.846	0.230	-3.674	0.000	***
Unit 3: Consumer Goods	-0.133	0.325	-0.409	0.683	
Unit 4: Materials & Sensors	-0.119	0.221	-0.536	0.592	
Unit 5: Components	-0.101	0.244	-0.413	0.680	
Unit 6: Manufacturing Tech.	0.014	0.221	0.063	0.950	
Responsibility	-0.346	0.200	-1.734	0.084	.
Process satisfaction	0.264	0.050	5.227	0.000	***
F-statistic: 7.853 on 7 and 372 DF	p-value: 6.976e-09				
Residual standard error: 1.297 on 372 degrees of freedom					
Multiple R^2: 0.1287	**Adjusted R^2: 0.1123**				

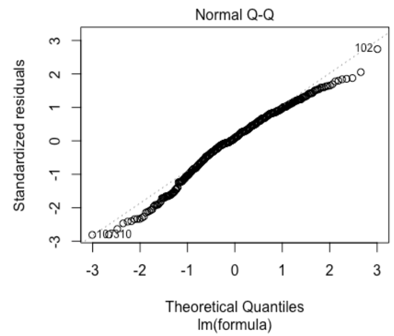
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



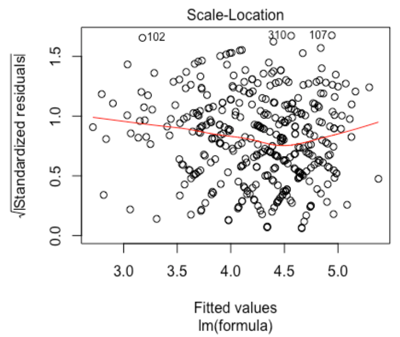
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



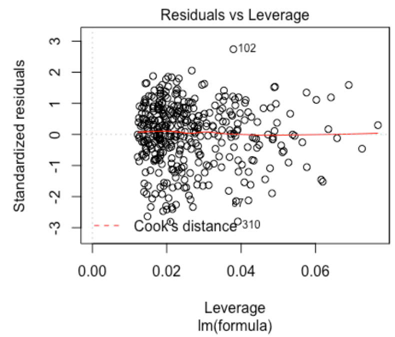
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for technology intelligence

Model 2: controls & main effects

Dependent variable: application of innovation fields for technology intelligence

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.564	0.536	6.643	0.000	***
Competitive intensity	-0.115	0.072	-1.603	0.110	
Technology orientation	0.138	0.065	2.113	0.035	*
Responsibility	-0.399	0.200	-1.995	0.047	*
Process satisfaction	0.173	0.057	3.055	0.002	**
Unit 2: Software Systems	-1.040	0.234	-4.444	0.000	***
Unit 3: Consumer Goods	-0.322	0.324	-0.996	0.320	
Unit 4: Materials & Sensors	-0.241	0.222	-1.088	0.277	
Unit 5: Components	-0.288	0.247	-1.164	0.245	
Unit 6: Manufacturing Tech.	-0.149	0.225	-0.661	0.509	
F-statistic: 7.152 on 10 and 369 DF	p-value: 2.531e-10				
Residual standard error: 1.277 on 369 degrees of freedom					
Multiple R^2: 0.1624	**Adjusted R^2: 0.1397**				

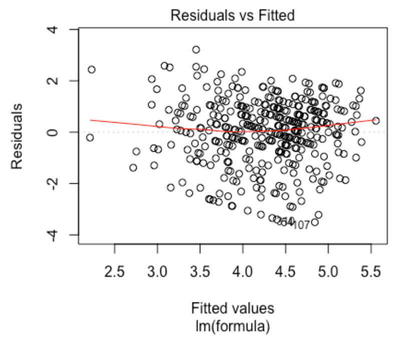
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Competitive intensity	1.0720
Technology orientation	1.3505
Responsibility	1.0843
Process satisfaction	1.4416
Unit factor	1.2375

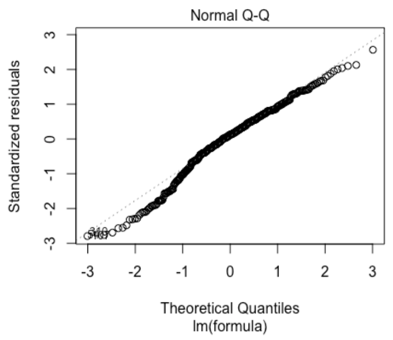
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



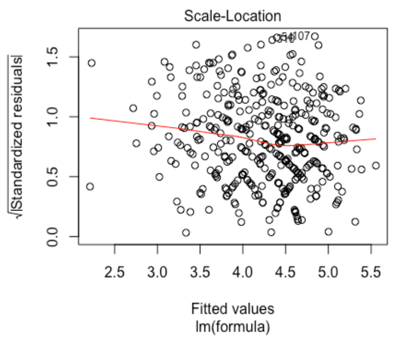
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



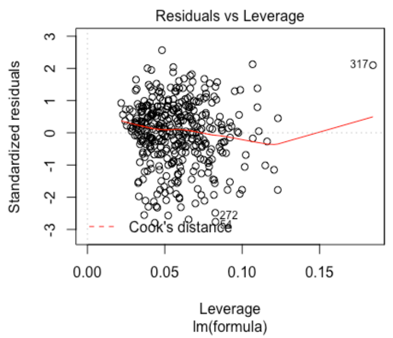
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for technology intelligence

Final model

Controls & quadratic main effects

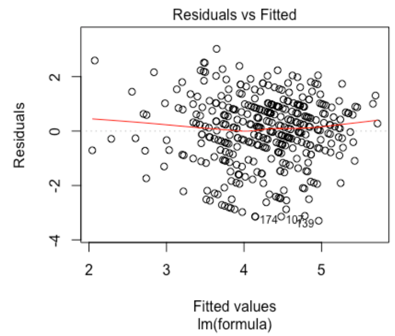
Dependent variable: application of innovation fields for technology intelligence					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-0.707	1.856	-0.381	0.704	
Technology orientation	0.122	0.071	1.729	0.085	.
Exploration	0.128	0.066	1.938	0.053	.
Competitive intensity	1.549	0.688	2.252	0.025	*
Competitive intensity^2	-0.155	0.064	-2.435	0.015	*
Unit 2: Software Systems	-1.024	0.233	-4.406	0.000	***
Unit 3: Consumer Goods	-0.353	0.322	-1.094	0.275	
Unit 4: Materials & Sensors	-0.253	0.221	-1.147	0.252	
Unit 5: Components	-0.231	0.247	-0.936	0.350	
Unit 6: Manufacturing Tech.	-0.145	0.224	-0.645	0.519	
Process Satsfaction	0.187	0.055	3.416	0.001	***
Responsibility	-0.371	0.199	-1.868	0.063	.
F-statistic: 7.017 on 11 and 368 DF	p-value: 8.196e-11				
Residual standard error: 1.27 on 368 degrees of freedom					
Multiple R^2: 0.1734	**Adjusted R^2: 0.1487**				

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Calculation of inflection points

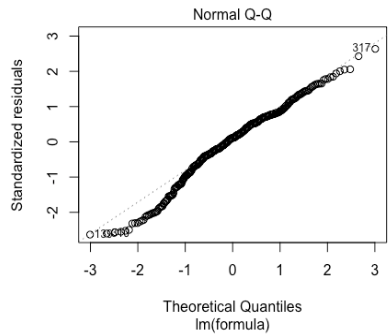
	Coefficients	Inflection point
Competitive intensity	1.566	
Competitive intensity^2	-0.156	5.032

Residuals Fitted Plot



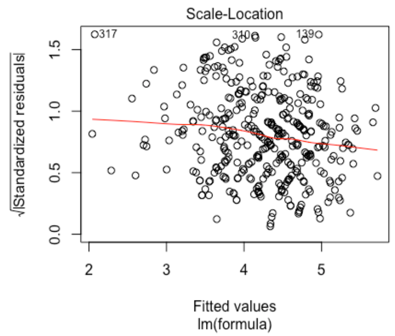
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



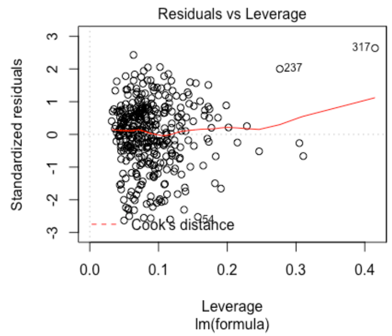
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for portfolio extension

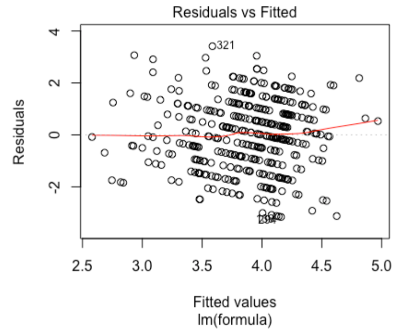
Application of innovation fields for portfolio extension

Model 1: controls

Dependent variable: application of innovation fields for portfolio extension					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.827	0.319	11.980	0.000	***
Unit 2: Software Systems	-0.788	0.241	-3.264	0.001	**
Unit 3: Consumer Goods	-0.258	0.341	-0.757	0.449	
Unit 4: Materials & Sensors	-0.244	0.232	-1.050	0.294	
Unit 5: Components	0.093	0.256	0.362	0.717	
Unit 6: Manufacturing Tech.	-0.240	0.233	-1.032	0.303	
Company tenure	0.013	0.009	1.558	0.120	
Responsibility	-0.423	0.213	-1.990	0.047	*
Process satisfaction	0.160	0.054	2.990	0.003	**
F-statistic: 3.93 on 8 and 371 DF	p-value: 0.0001782				
Residual standard error: 1.358 on 371 degrees of freedom					
Multiple R^2: 0.07812	**Adjusted R^2: 0.05824**				

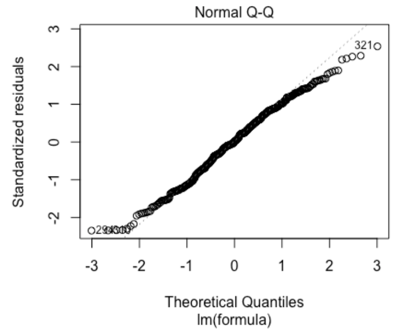
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



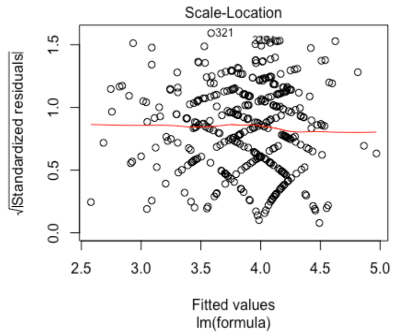
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



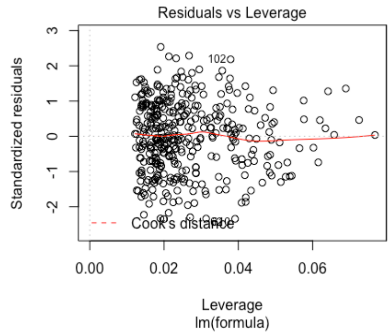
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for portfolio extension

Final model

Controls & main effects

Dependent variable: application of innovation fields for portfolio extension					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.534	0.575	6.142	0.000	***
Technology orientation	0.149	0.068	2.210	0.028	*
Technology turbulence	0.191	0.072	2.642	0.009	**
Competitive intensity	-0.191	0.077	-2.489	0.013	*
Unit 2: Software Systems	-0.979	0.244	-4.014	0.000	***
Unit 3: Consumer Goods	-0.226	0.347	-0.653	0.514	
Unit 4: Materials & Sensors	-0.361	0.232	-1.556	0.121	
Unit 5: Components	0.013	0.263	0.050	0.960	
Unit 6: Manufacturing Tech.	-0.273	0.242	-1.125	0.261	
Process satisfaction	0.097	0.057	1.711	0.088	.
Responsibility	-0.471	0.212	-2.221	0.027	*
Company tenure	0.014	0.008	1.654	0.099	.
F-statistic: 4.666 on 11 and 368 DF	p-value: 1.105e-06				
Residual standard error: 1.33 on 368 degrees of freedom					
Multiple R^2: 0.1224	**Adjusted R^2: 0.09616**				

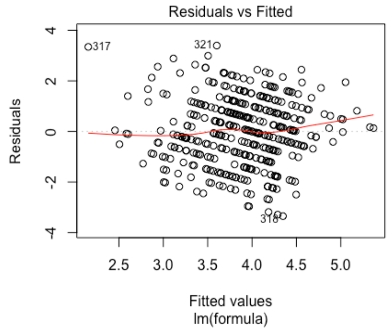
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Technology turbulence	1.328
Competitive intensity	1.138
Technology orientation	1.335
Unit factor	1.469
Company tenure	1.111
Responsibility	1.122
Process satisfaction	1.326

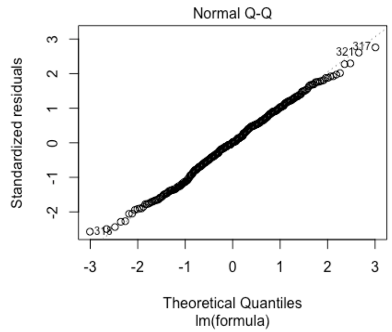
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



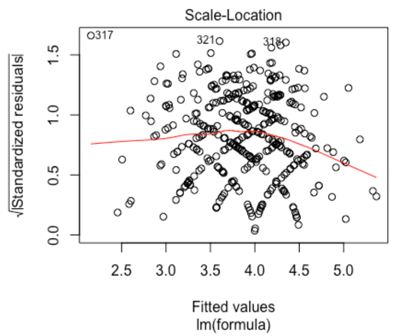
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



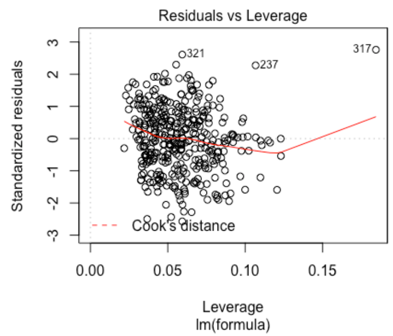
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Application of innovation fields for portfolio extension

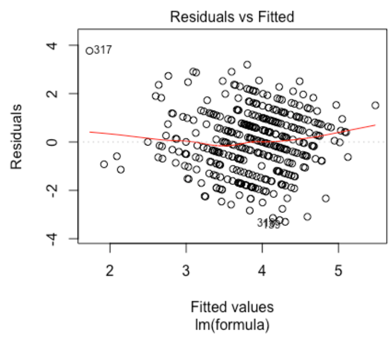
Model 3: controls & quadratic main effects

Dependent variable: application of innovation fields for portfolio extension

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	-0.135	1.296	-0.104	0.917	
Technology turbulence	0.212	0.081	2.618	0.009	**
Market turbulence	0.698	0.454	1.537	0.125	
Customer orientation	0.806	0.390	2.068	0.039	*
Technology orientation	0.129	0.071	1.825	0.069	.
Competitive intensity^2	-0.019	0.007	-2.642	0.009	**
Market turbulence^2	-0.080	0.051	-1.581	0.115	
Customer orientation^2	-0.082	0.039	-2.076	0.039	*
Unit 2: Software System	-0.953	0.243	-3.919	0.000	***
Unit 3: Consumer Good:	-0.164	0.348	-0.473	0.636	
Unit 4: Materials & Sens	-0.342	0.231	-1.480	0.140	
Unit 5: Components	-0.021	0.264	-0.078	0.938	
Unit 6: Manufacturing Te	-0.292	0.242	-1.206	0.229	
Company tenure	0.015	0.009	1.775	0.077	.
Responsibility	-0.475	0.211	-2.250	0.025	*
Process satisfaction	0.080	0.057	1.407	0.160	
F-statistic: 4.048 on 15 and 364 DF		p-value: 7.754e-07			
Residual standard error: 1.321 on 364 degrees of freedom					
Multiple R^2: 0.143		**Adjusted R^2: 0.1077**			

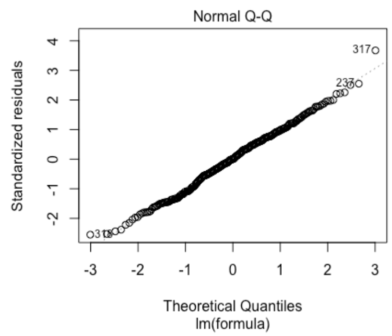
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



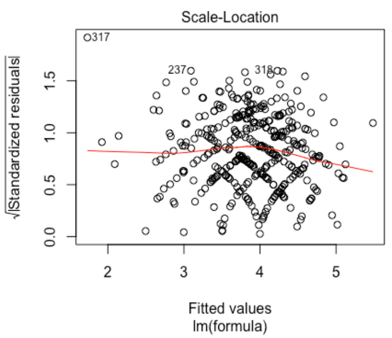
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



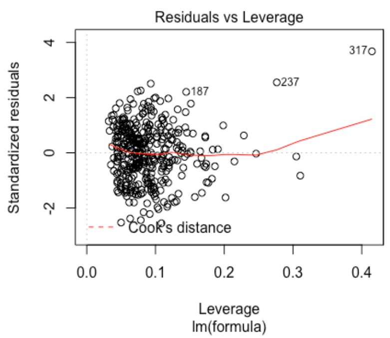
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Perceived usefulness of innovation fields

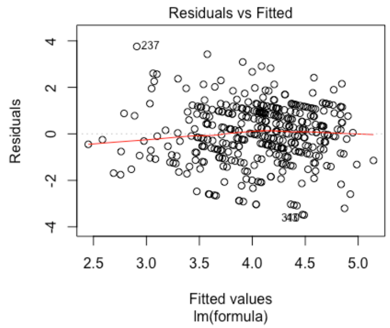
Perceived usefulness of innovation fields

Model 1: controls

Dependent variable: perceived usefulness of innovation fields					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.707	0.297	12.475	0.000	***
Unit 2: Software Systems	-0.793	0.224	-3.540	0.000	***
Unit 3: Consumer Goods	-0.056	0.316	-0.177	0.860	
Unit 4: Materials & Sensors	-0.044	0.215	-0.203	0.839	
Unit 5: Components	-0.064	0.238	-0.271	0.787	
Unit 6: Manufacturing Tech.	-0.314	0.216	-1.456	0.146	
Responsibility	-0.468	0.195	-2.407	0.017	*
Process satisfaction	0.270	0.049	5.502	0.000	***
F-statistic: 7.923 on 7 and 372 DF	p-value: 5.741e-09				
Residual standard error: 1.263 on 372 degrees of freedom					
Multiple R^2: 0.1297	**Adjusted R^2: 0.1134**				

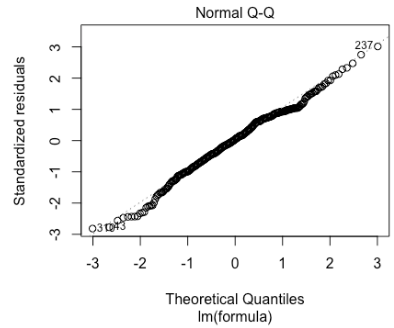
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



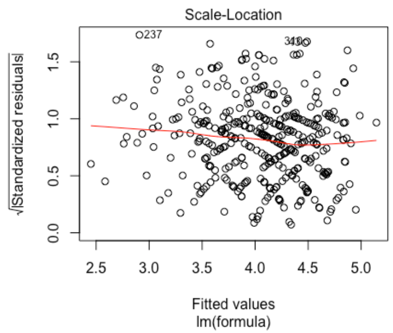
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



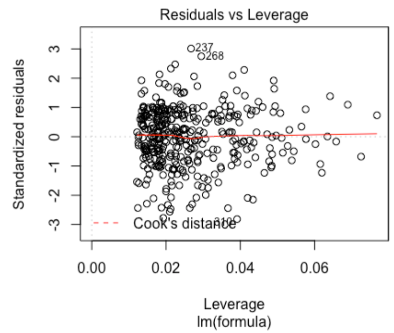
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Perceived usefulness of innovation fields

Model 2: controls & main effects

Dependent variable: perceived usefulness of innovation fields

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.822	0.504	7.585	0.000	***
Competitive intensity	-0.118	0.070	-1.695	0.091	.
Exploration	0.178	0.058	3.070	0.002	**
Unit 2: Software Systems	-0.923	0.226	-4.085	0.000	***
Unit 3: Consumer Goods	-0.193	0.315	-0.615	0.539	
Unit 4: Materials & Sensors	-0.142	0.215	-0.661	0.509	
Unit 5: Components	-0.135	0.236	-0.571	0.568	
Unit 6: Manufacturing Tech.	-0.389	0.217	-1.790	0.074	.
Responsibility	-0.446	0.194	-2.298	0.022	*
Process satisfaction	0.213	0.053	4.032	0.000	***
F-statistic: 7.616 on 9 and 370 DF	p-value: 2.861e-10				
Residual standard error: 1.247 on 370 degrees of freedom					
Multiple R^2: 0.1563	**Adjusted R^2: 0.1358**				

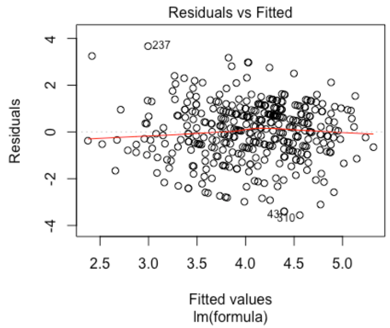
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Competitive intensity	1.0729
Exploration	1.2471
Unit factor	1.1941
Responsibility	1.0680
Process satisfaction	1.3137

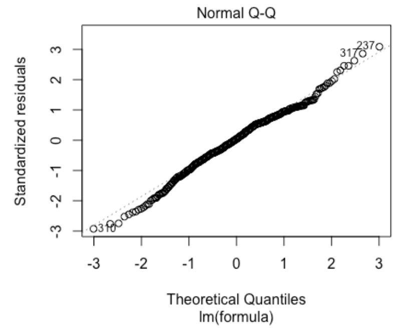
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



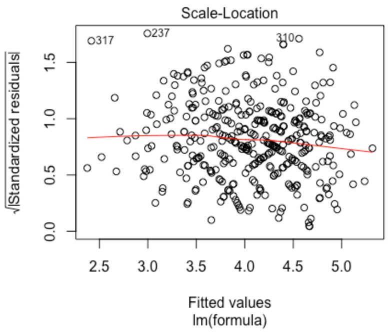
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



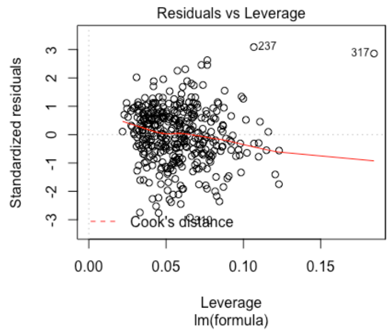
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Perceived usefulness of innovation fields

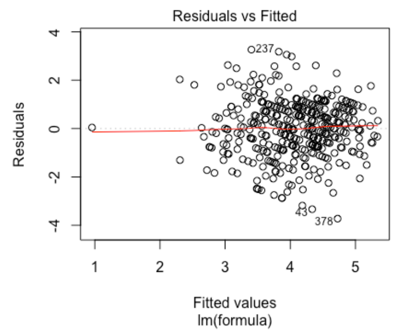
Model 3: controls & quadratic main effects

Dependent variable: perceived usefulness of innovation fields

	Estimate	Std.Error	t-value	Pr(>|t|)	Sig
(Intercept)	-0.045	1.416	-0.032	0.975	
Market turbulence	0.715	0.422	1.693	0.091	.
Customer orientation	1.084	0.371	2.922	0.004	**
Formalization	0.500	0.317	1.578	0.115	
Connectedness	-0.597	0.359	-1.666	0.097	.
Exploration	0.121	0.066	1.823	0.069	.
Competitive intensity^2	-0.014	0.007	-2.101	0.036	*
Market turbulence^2	-0.071	0.047	-1.503	0.134	
Customer orientation^2	-0.108	0.037	-2.894	0.004	**
Formalization^2	-0.059	0.035	-1.694	0.091	.
Connectedness^2	0.068	0.039	1.720	0.086	.
Unit 2: Software Systems	-0.860	0.229	-3.758	0.000	***
Unit 3: Consumer Goods	-0.006	0.320	-0.018	0.986	
Unit 4: Materials & Sensors	-0.094	0.214	-0.437	0.662	
Unit 5: Components	-0.185	0.236	-0.785	0.433	
Unit 6: Manufacturing Tech.	-0.430	0.220	-1.957	0.051	.
Responsibility	-0.459	0.192	-2.393	0.017	*
Process satisfaction	0.199	0.054	3.725	0.000	***
F-statistic: 5.303 on 17 and 362 DF		p-value: 1.601e-10			
Residual standard error: 1.228 on 362 degrees of freedom					
Multiple R^2: 0.1994		**Adjusted R^2: 0.1618**			

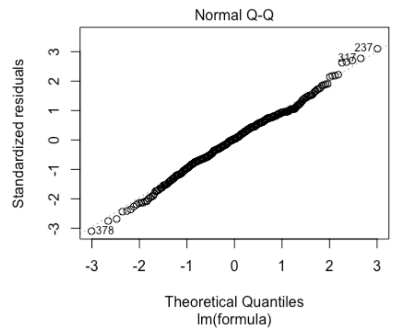
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



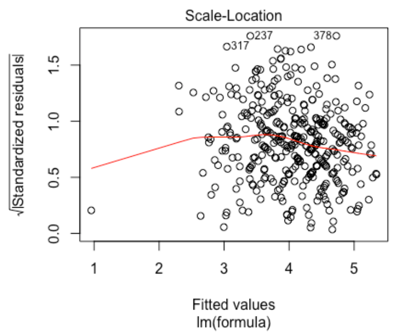
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



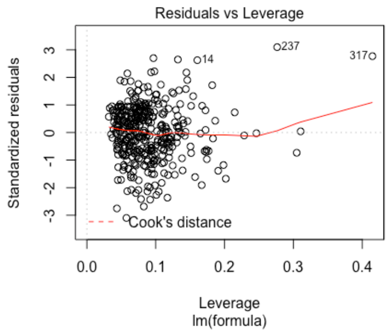
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Perceived usefulness of innovation fields

Final model (excluding competitive intensity)

Controls & quadratic main effects

Dependent variable: perceived usefulness of innovation fields

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-0.512	1.405	-0.364	0.716	
Customer orientation	1.012	0.371	2.726	0.007	**
Customer orientation^2	-0.102	0.038	-2.732	0.007	**
Exploration	0.120	0.067	1.799	0.073	.
Formalization	-0.501	0.318	1.573	0.117	
Formalization^2	0.059	0.035	-1.687	0.092	.
Connectedness	-0.561	0.360	-1.558	0.120	
Connectedness^2	0.064	0.040	1.627	0.105	
Market turbulence	0.799	0.423	1.891	0.059	.
Market turbulence^2	-0.082	0.047	-1.740	0.083	.
Unit 2: Software Systems	-0.766	0.225	-3.398	0.001	***
Unit 3: Consumer Goods	0.041	0.321	0.127	0.899	
Unit 4: Materials & Sensors	-0.034	0.213	-0.161	0.872	
Unit 5: Components	-0.126	0.236	-0.534	0.594	
Unit 6: Manufacturing Tech.	-0.331	0.216	-1.534	0.126	
Process satisfaction	0.196	0.054	3.647	0.000	***
Responsibility	-0.513	0.191	-2.687	0.008	**
F-statistic: 5.309 on 16 and 363 DF		p-value: 4.198e-10			
Residual standard error: 1.234 on 363 degrees of freedom					
Multiple R^2: 0.1896		**Adjusted R^2: 0.1539**			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Calculation of inflection points

	Coefficients	Inflection point
Market turbulence	0.779	
Market turbulence^2	-0.080	4.840
Customer orientation	1.003	
Customer orientation^2	-0.102	4.899
Formalization	-0.533	
Formalization^2	0.063	4.217
Connectedness	-0.530	
Connectedness^2	0.062	4.263

Likelihood ratio test: competitive intensity

Model 1: including competitive intensity
Model 2: excluding competitive intensity

	#Df	**LogLik**	**Df**	**Chisq**	**Pr(>Chisq)**	**Sig**
1	20	-607.43				
2	18	-610.35	-2	5.8232	0.05439	.

With regards to content, competitive intensity will be excluded, although weak significant likelihood ratio test

Appendix A11
Overview of Regression Models
Innovation fields enhancing performance

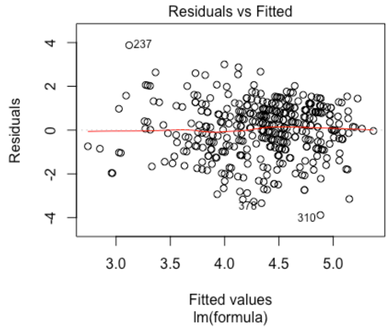
Model 1: controls

Dependent variable: innovation fields enhancing performance

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.948	0.298	13.247	0.000	***
Unit 2: Software Systems	-0.824	0.225	-3.663	0.000	***
Unit 3: Consumer Goods	-0.170	0.317	-0.536	0.592	
Unit 4: Materials & Sensors	-0.023	0.216	-0.107	0.915	
Unit 5: Components	0.016	0.238	0.066	0.947	
Unit 6: Manufacturing Tech.	-0.269	0.216	-1.243	0.215	
Responsibility	-0.420	0.195	-2.154	0.032	*
Process satisfaction	0.262	0.049	5.329	0.000	***
F-statistic: 7.829 on 7 and 372 DF	p-value: 7.449e-09				
Residual standard error: 1.267 on 372 degrees of freedom					
Multiple R^2: 0.1284	**Adjusted R^2: 0.112**				

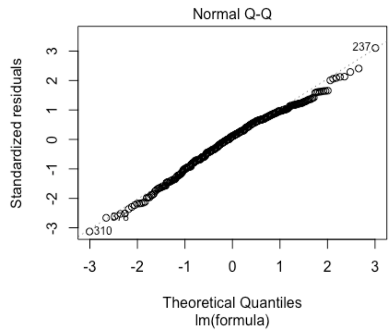
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



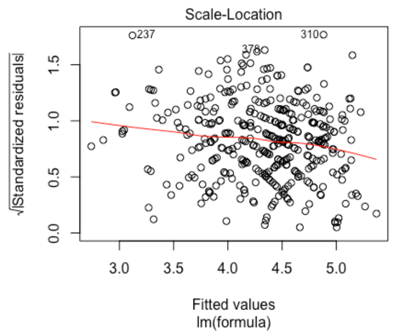
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



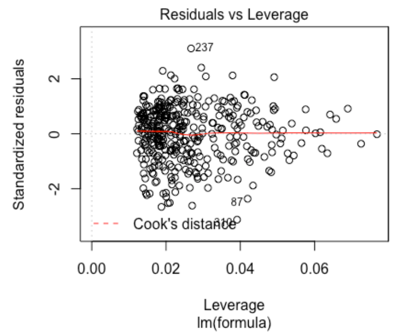
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Innovation fields enhancing performance

Model 2: controls & main effects

Dependent variable: innovation fields enhancing performance

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.568	0.567	6.294	0.000	***
Technology turbulence	0.102	0.068	1.502	0.134	
Competitive intensity	-0.127	0.072	-1.761	0.079	.
Connectedness	0.097	0.060	1.632	0.104	
Unit 2: Software Systems	-0.885	0.228	-3.876	0.000	***
Unit 3: Consumer Goods	-0.154	0.322	-0.478	0.633	
Unit 4: Materials & Sensors	-0.061	0.216	-0.284	0.776	
Unit 5: Components	0.007	0.241	0.030	0.976	
Unit 6: Manufacturing Tech.	-0.228	0.225	-1.014	0.311	
Responsibility	-0.448	0.196	-2.285	0.023	*
Process satisfaction	0.199	0.055	3.649	0.000	***
F-statistic: 6.19 on 11 and 368 DF	p-value: 2.321e-09				
Residual standard error: 1.253 on 368 degrees of freedom					
Multiple R^2: 0.1561	**Adjusted R^2: 0.1309**				

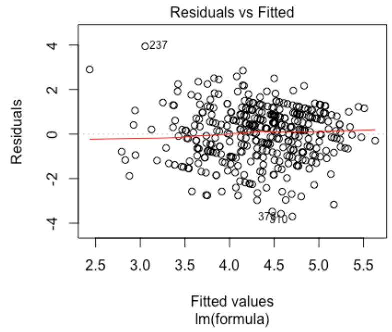
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Technology turbulence	1.3104
Competitive intensity	1.1394
Connectedness	1.1493
Unitf factor	1.3919

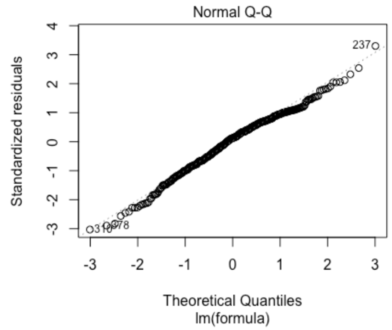
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



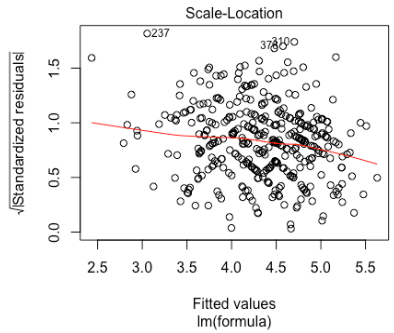
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



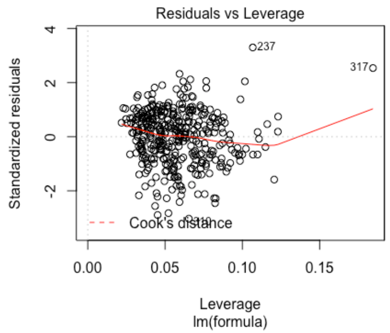
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

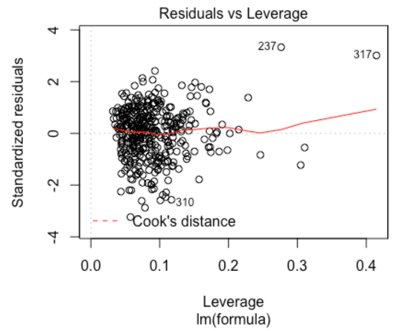
Appendix A11
Overview of Regression Models
Innovation fields enhancing performance

Model 3: controls & quadratic main effects

Dependent variable: innovation fields enhancing performance					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-2.818	1.937	-1.455	0.147	
Technology turbulence	0.123	0.066	1.865	0.063	.
Competitive intensity	1.550	0.675	2.297	0.022	*
Customer orientation	1.054	0.356	2.964	0.003	**
Competitive intensity^2	-0.158	0.062	-2.531	0.012	*
Customer orientation^2	-0.101	0.036	-2.800	0.005	**
Connectedness^2	0.011	0.006	1.743	0.082	.
Unit 2: Software Systems	-0.860	0.225	-3.818	0.000	***
Unit 3: Consumer Goods	-0.115	0.317	-0.364	0.716	
Unit 4: Materials & Sensors	-0.035	0.213	-0.163	0.871	
Unit 5: Components	-0.021	0.238	-0.088	0.930	
Unit 6: Manufacturing Tech.	-0.255	0.223	-1.143	0.254	
Company tenure	0.011	0.008	1.399	0.163	
Responsibility	-0.471	0.196	-2.405	0.017	*
Process satisfaction	0.187	0.052	3.607	0.000	***
F-statistic: 6.144 on 14 and 365 DF	p-value: 5.421e-11				
Residual standard error: 1.232 on 365 degrees of freedom					
Multiple R^2: 0.1907	**Adjusted R^2: 0.1597**				

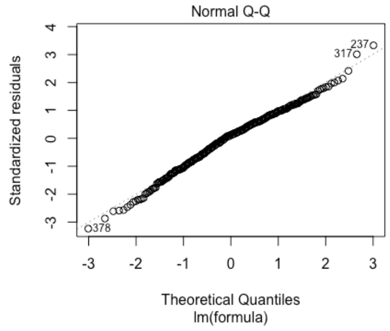
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residuals Fitted Plot



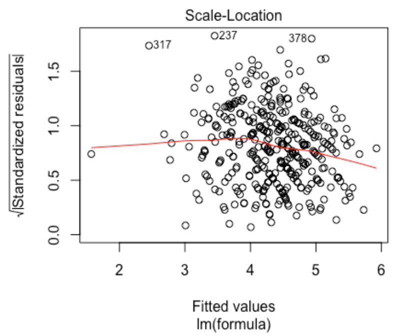
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



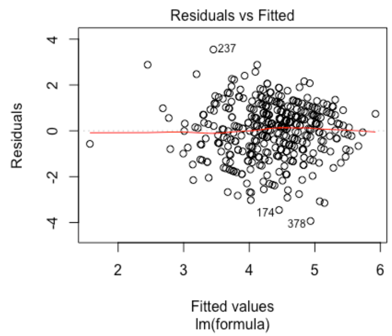
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Innovation fields enhancing performance

Final model (excluding connectedness)

Controls & quadratic main effects

Dependent variable: innovation fields enhancing performance					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-2.507	1.938	-1.294	0.197	
Customer orientation	1.073	0.356	3.015	0.003	**
Customer orientation^2	-0.101	0.036	-2.773	0.006	**
Technology turbulence	0.138	0.066	2.095	0.037	*
Competitive intensity	1.461	0.676	2.161	0.031	*
Competitive intensity^2	-0.150	0.062	-2.409	0.016	*
Unit 2: Software Systems	-0.927	0.224	-4.139	0.000	***
Unit 3: Consumer Goods	-0.132	0.316	-0.416	0.678	
Unit 4: Materials & Sensors	-0.067	0.213	-0.313	0.755	
Unit 5: Components	0.005	0.238	0.020	0.984	
Unit 6: Manufacturing Tech.	-0.329	0.221	-1.490	0.137	
Process satisfaction	0.210	0.051	4.132	0.000	***
Responsibility	-0.414	0.193	-2.142	0.033	*
F-statistic: 6.695 on 12 and 367 DF	p-value: 6.701e-11				
Residual standard error: 1.237 on 367 degrees of freedom					
Multiple R^2: 0.1796	**Adjusted R^2: 0.1528**				

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Calculation of inflection points

	Coefficients	Inflection point
Competitive intensity	1.457	
Competitive intensity^2	-0.149	4.886
Customer orientation	1.077	
Customer orientation2	-0.102	5.306

Likelihood ratio test: connectedness

Model 1: including connectedness
Model 2: excluding connectedness

	#Df	**LogLik**	**Df**	**Chisq**	**Pr(>Chisq)**	**Sig**
1	16	-611.69				
2	14	-613.51	-2	3.6499	0.1612	

Connectedness is excluded from the regressiion model.

Appendix A11
Overview of Regression Models
Innovation fields enhance innovativeness

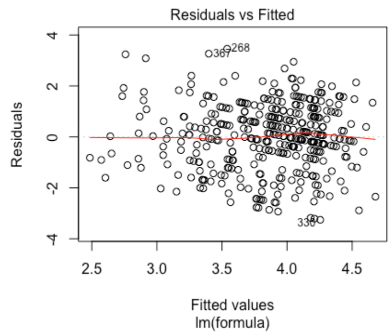
Innovation fields enhancing innovativeness

Model 1: controls

Dependent variable: innovation fields enhancing innovativeness					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.686	0.307	11.990	0.000	***
Unit 2: Software Systems	-0.977	0.232	-4.215	0.000	***
Unit 3: Consumer Goods	-0.448	0.327	-1.370	0.172	
Unit 4: Materials & Sensors	-0.250	0.223	-1.120	0.263	
Unit 5: Components	-0.166	0.246	-0.675	0.500	
Unit 6: Manufacturing Tech.	-0.328	0.223	-1.469	0.143	
Responsibility	-0.298	0.201	-1.479	0.140	
Process satisfaction	0.208	0.051	4.100	0.000	***
F-statistic: 5.803 on 7 and 372 DF	p-value: 2.123e-06				
Residual standard error: 1.307 on 372 degrees of freedom					
Multiple R^2: 0.09845	**Adjusted R^2: 0.08149**				

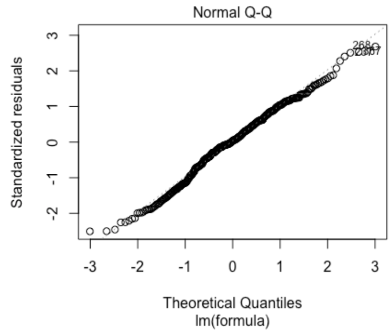
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



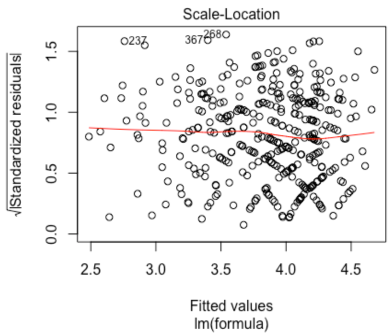
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



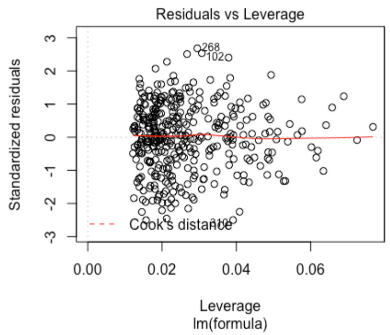
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Innovation fields enhance innovativeness

Final model

Controls & main effects

Dependent variable: innovation fields enhancing innovativeness					
	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	3.398	0.554	6.138	0.000	***
Technology turbulence	0.137	0.077	1.768	0.078	.
Competitive intenstiy	-0.134	0.075	-1.795	0.073	.
Market turbulence	0.106	0.073	1.446	0.149	
Unit 2: Software Systems	-1.058	0.233	-4.535	0.000	***
Unit 3: Consumer Goods	-0.273	0.331	-0.824	0.410	
Unit 4: Materials & Sensors	-0.277	0.222	-1.247	0.213	
Unit 5: Components	-0.149	0.249	-0.597	0.551	
Unit 6: Manufacturing Tech.	-0.280	0.230	-1.215	0.225	
Process satisfaction	0.181	0.051	3.507	0.001	***
Responsibility	-0.312	0.202	-1.546	0.123	
F-statistic: 5.267 on 10 and 369 DF	p-value: 2.956e-07				
Residual standard error: 1.293 on 369 degrees of freedom					
Multiple R^2: 0.1249	**Adjusted R^2: 0.1012**				

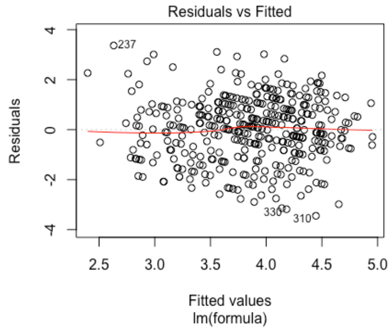
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Test for multicollinearity with Variance Inflation Factor (VIF)

Technology turbulence	1.2927
Competitive intenstiy	1.1371
Unit factor	1.3370
Responsibility	1.0819

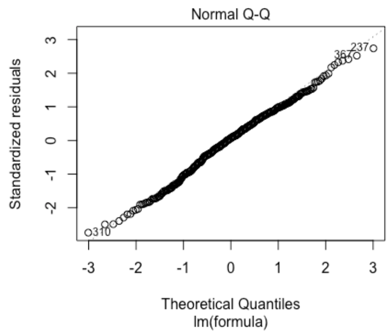
No multicollinearity detected, all values close to 1 and not > 10

Residuals Fitted Plot



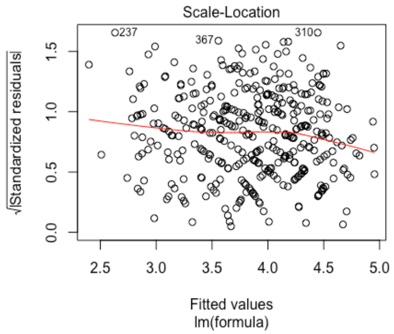
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



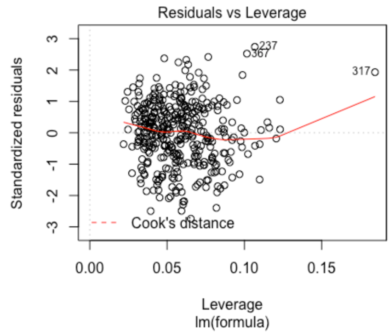
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)

Appendix A11
Overview of Regression Models
Innovation fields enhance innovativeness

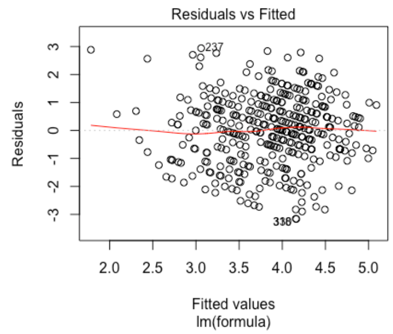
Model 3: controls & quadratic main effects

Dependent variable: innovation fields enhancing innovativeness

	Estimate	**Std.Error**	**t-value**	**Pr(>|t|)**	**Sig**
(Intercept)	-2.925	2.200	-1.330	0.185	
Technology turbulence	0.869	0.461	1.884	0.060	.
Competitive intenstiy	1.232	0.707	1.743	0.082	.
Customer orientation	0.612	0.370	1.652	0.099	.
Technology turbulence^2	-0.073	0.048	-1.528	0.127	
Competitive intenstiy^2	-0.127	0.065	-1.938	0.053	.
Customer orientation^2	-0.059	0.038	-1.556	0.121	
Unit 2: Software Systems	-1.066	0.233	-4.575	0.000	***
Unit 3: Consumer Goods	-0.351	0.332	-1.059	0.291	
Unit 4: Materials & Sensors	-0.284	0.221	-1.288	0.199	
Unit 5: Components	-0.155	0.247	-0.627	0.531	
Unit 6: Manufacturing Tech.	-0.354	0.230	-1.540	0.124	
Responsibility	-0.348	0.201	-1.732	0.084	.
Process satisfaction	0.138	0.056	2.472	0.014	*
F-statistic: 4.048 on 15 and 364 DF		p-value: 7.754e-07			
Residual standard error: 1.321 on 364 degrees of freedom					
Multiple R^2: 0.143		**Adjusted R^2: 0.1077**			

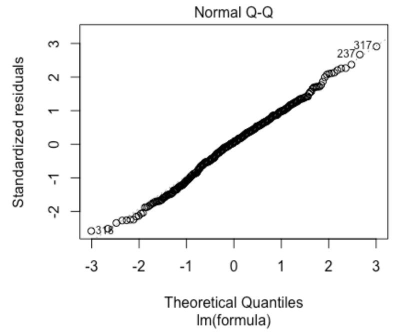
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residuals Fitted Plot



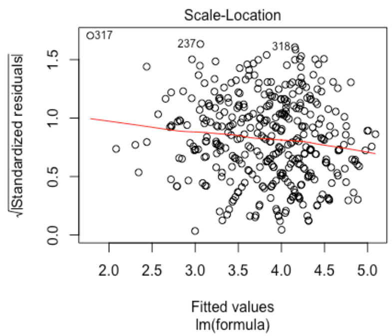
Correct specification of the model: red Lowess-line parallel to X-axis and values scattered.

Normal Q-Q Plot



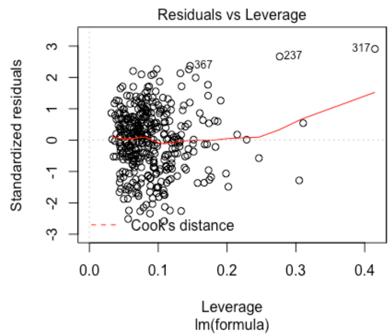
Normal distribution of residuals due to diagonal progression

Scale-Location Plot



Homoscedacity given due to scattered distribution.

Residuals vs. Leverage



No influential outliers; no data points outside of cook's distance measures.

Test for multiple regression parameters (cf. Luhmann 2015, p.233ff)